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CANALS, ANCIENT AND MODERN.—I.*

THE services rendered to mankind by the canal engineer have of late years been signally undervalued in England. Over a century and a half ago there were in England no canals, railways, artificial harbors, or machinery, and the public roads were little better than mere tracks across the country. The inland commerce of this country was chiefly carried by transport on the backs of pack horses. Inland water carriage was tedious and uncertain; it was only carried on on the rivers as Nature had left them, and was interrupted at one time by drought, at another by flood. The perseverance of Francis, Duke of Bridgwater, and of his engineer, James Brindley, whom the duke withdrew from his occupation as a millwright in opening a waterway for the supply of Manchester with coal from the duke's colliery, was the commencement of a great revolution in the material welfare of the country.

In the history of ancient nations we discover various traces of canals, formed for military, agricultural, commercial, or other purposes. We learn from Herodotus that the Cridians, a people of Caria, in Asia Minor, formed a design of digging a channel through the isthmus which joined their territory to the continent, but they relinquished the undertaking because they were interdicted by an oracle. Both the Greeks and Romans proposed to make a canal across the Isthmus of Corinth, which joins Morea and Achaia, and thus to make a navigable passage by the Ionian Sea into the Archipelago. Demetrius Poliorcetes, Julius Cæsar, Nero, and Caligula renewed the attempt but without success. The Romans, more intent on conquests than on commerce and marts, afford us few instances of canals for internal navigation. Lucius Verus, who commanded the Roman army in Gaul under Nero, attempted to make a canal between the Moselle and the Rhine.

Corbulo, under Claudius, employed his soldiers in digging a canal between the Rhine and the Meuse, for a space of about twenty-three miles, in order to preserve the country from inundation, and to serve as a drain in case of any extraordinary overflowings of the sea. Claudius also employed 30,000 men for about twelve years in digging a canal through a mountain for the draining the lake Fucinus—now Celano—into the river Liris; and in 1789 this canal was begun to be cleansed, to the great relief of the neighboring country, which was inundated by its obstruction. The Romans during their residence in this country made a canal between the Nene, a little below Peterborough, and the Witham, three miles below Lincoln, which is now almost wholly filled up. It was almost 40 miles long, and, as far as may be judged from the ruins, very broad and deep. Some have supposed it to be a Danish work. Morton, in his History of Northamptonshire, Chapter 10, supposes it to have been made under the Emperor Domitian. Urns and medals have been discovered on the banks of this canal, which seem to confirm that opinion.

Charlemagne, at a later period, formed a design of joining the Rhine and the Danube, and of thus making a communication between Mocean and the Black Sea. In the execution of this design he employed a great number of workmen, but he was prevented from completing it by a variety of obstructions which occurred. Of all the countries to which ancient history directs our attention, Egypt was the most distinguished by its numerous canals, which amounted to eighty, several

A TYPICAL SCENE ON A DELFT CANAL, HOLLAND.

* London Engineer.

of which are 20, 30, and 40 leagues in length. These served to receive and distribute the waters of the Nile at the time of its inundation.

But the principal of these works was the Grand Canal, by which a communication was made between the Nile and the Red Sea. This was begun, according to Herodotus, by Necos, the son of Psammitichus, who desisted from the attempt on an answer from the oracles, after having lost 120,000 men in the enterprise. Strabo—lib. xvii., p. 1157, ed. Casaubon—attributes the commencement of it to Sesostris, before the Trojan war. It was resumed and carried on by Darius, son of Hystaspes, who relinquished the work on the representation made to him by unskillful engineers that the Red Sea, being higher than the land of Egypt, would overwhelm and drown the whole country. Ptolemy II., however, finished the undertaking. Pliny, in his account of this canal—lib. vi., c. 29—gives its breadth as 100 feet, its depth as 40 feet, and its length as 37 miles. By means of this canal the valuable commodities of India, Persia, Arabia, and the kingdoms on the coast of Africa, which were brought by shipping to the Red Sea, were conveyed to the Nile, and thence distributed by the Mediterranean not only to Greece and Rome but to all the surrounding nations, until the Portuguese discovered a passage to India by the Cape of Good Hope. It did not, however, long serve the useful purposes of commerce which were at first expected. Merchants were dissatisfied with the delay occasioned by going to the very bottom of the gulf, and afterward with the inland navigation of the canal, and that of the Nile to Alexandria. They found it more expeditious to unload at Berenice, near the coast of the Red Sea, and after three days' journey to send their merchandise directly down to Alexandria. Accordingly, this canal was disused, and goods were conveyed from Berenice to the Nile by land. Strabo and others have asserted that this canal was again opened about the year 635 by Amru, governor or prefect of Egypt, under the Caliph Omar, for the conveyance of the corn of Egypt to Arabia, which was then grievously distressed by a famine. Egypt is intersected in various directions by many other canals.

There is no country on the face of the globe that abounds more with canals and navigable rivers than China. In China there is scarcely a town, or even a village, which has not the advantage either of an arm of the sea or a canal, by which means navigation is rendered so common that almost as many people live on the water as on land. The great canal is one of the wonders of art; it runs from north to south, extending from the city of Canton to the extremity of the empire, and by it all kinds of foreign merchandise entered at that city is conveyed directly to Peking, a distance of 825 miles. This canal is about 50 feet wide; it passes through, or near, forty-one large cities; it has seventy-five large sluices to keep up the water, besides several thousand bridges.

China owes the greatest part of her riches to these numerous canals, which are cut through any kind of property, not even excepting the gardens of the Emperor. The canals are bordered or faced with quays of freestone, and in low places long causeways are raised for the convenience of travelers. There are bridges over the canals of three, four or more arches, of which the middle one is high enough for vessels to pass under with their masts standing. When the water is liable to overflow the neighboring meadows, the sluices are opened to convey it away, and there are inspectors appointed to keep the canals in proper repair. One large canal generally runs through every province, and a vast number of smaller ones are cut from the large one, which again are divided into some still smaller, that end at a village or great town. Sometimes they discharge into a lake or large pond, from which all the adjacent country is watered. Among all the canals in the southern provinces, one is called the Great Canal, which is the grandest inland navigation in the world, being 1,000 feet in width, of which the sides are built with massive blocks of gray marble mixed with others of granite; and this immense canal, although forced several feet above the surface of the country by embankments thrown up by the labor of man, flows with a current of about three miles an hour toward the Yellow River. That which most charms the eye is the immense number of large boats with imperial colors, and beautifully painted, that sail in fleets, commanded by a single mandarin of the province. There are several classes or rates of these boats, very neat and commodious. Some of these boats are of 200 tons burden, and from 300 to 400 of them may be seen on the same canal at the same time, and sometimes in one fleet.

Hindostan likewise furnishes instances at a remote period of the acknowledged importance and utility of canals. As the country between Delhi and Punjab was scantily supplied with water, the emperor Ferose III., who died in 1388, undertook the task of supplying it better, and at the same time of applying the water so furnished to the purposes of navigation. The immediate object of the canals projected and executed by Ferose seems to have been the junction of the Sutlej and Jumnah rivers through an interval of 240 geographical miles, and, remotely, that of the Indus and Ganges. If this grand design of Ferose had been completed, it must have ranked with the greatest works of this kind, "for we should then have seen two capital rivers, which traverse a large part of Southern Asia, which enter the sea at the distance of 1,500 British miles asunder, and which stretch out their arms, as it were, to meet each other, united by art and those by Nature to a third; so as to form an uninterrupted inland navigation from the frontiers of China to those of Persia." The country of Bengal is so intersected in various directions by the natural canals of the Ganges and Brahmapootra rivers, together with their numerous branches, as to form the most complete and easy navigation that can be conceived.

The improvement of inland navigation engaged but little attention in Russia before the reign of Peter the Great. With him, after his return from Holland, where he had observed its useful effects, the construction of canals became a principal object. Of those projected and hastily executed by him, may be mentioned that of Cronstadt, that of Ladoga, that of Vishnei-Voloshok, and that for forming a communication between Moscow and the Don.

The canals of Holland and Flanders are innumerable, and they serve the purpose of our public roads, so that the inhabitants may travel by means of them in their trekhuyts and barges, and convey commodities for consumption or exportation from one part of the country to another, as occasion requires. By them also a prodigious inland trade is carried on between Holland, France, Flanders, and Germany. When the canals are frozen over, the people travel on them with skates, and perform long journeys in a very short time, while heavy burdens are conveyed in carts and sledges, which are there as much used on the canals as in our streets. The profits which have accrued from these canals have been immense.

The canals of Holland are generally 60 feet wide and 6 feet deep, and are kept cleansed, the mud as manure being very profitable. They are generally level, and need no locks. In the province of Delftland, not more than 60 miles long, over 200 windmills are employed in spring to raise the water into the canals. On the dams or banks by which they are bordered, and which are kept in repair at a very considerable expense, depends the security of the country from inundation.

The canals of Flanders, ever since their trade has declined, and the cities erected on their banks have decayed, have been very much neglected. They indicate, however, the former flourishing and prosperous state of the country. So early as the twelfth century large canals were cut; and they answered the purpose of inland commerce, as well as of draining the land. The spacious canal at Brussels, begun in 1531 and completed in 1560, extends from this city to the Scheldt, which opens a communication with Holland, and by the canals of Flanders with the ocean.

(To be continued.)

HERBERT SPENCER AS AN ENGINEER.

THE devotion of Herbert Spencer to the study of philosophy has somewhat obscured the fact that he was ever any other than a philosopher. His autobiography shows, by the very considerable amount of detail he gives of his early professional life, that he himself had by no means forgotten it; and it may be interesting to inquire what he was likely to have become had he continued to follow his original calling. This question may very well be considered in connection with the progress he had already made up to the time that he abandoned the precincts of Great George Street, and by any contributions he may have made to engineering knowledge; that he had a great liking for the work is evident from the interest he took in it. Articled in the year 1837, at the age of seventeen, to a railway engineer, he seems to have applied himself with ardor to the study of the profession he, ten years later, relinquished, and appears soon to have reached the conclusion that he had something to communicate to the engineering world. This is evidenced by certain contributions he made to the Civil Engineers' and Architects' Journal in the form of letters and signed articles, the first of which, appearing in May, 1839, was upon "Skew Arches," and contained a demonstration of the principle involved in describing spiral courses for such an arch, and a convenient method of reproducing the line so determined, upon a drawing, as often as may be required. This letter, dated from the Birmingham & Gloucester Railway office at Worcester, suggests that he was engaged in office work at that time. There is nothing remarkable about the letter as an addition to engineering literature; but the matter was then, no doubt, of more interest than now, was clearly expressed, and would be of service to many young engineers of his day.

Of much more importance as a piece of reasoning is that found in a letter headed "A Geometrical Theorem," and dated, as in the previous case, from Gloucester, appearing in July, 1840. It is probable that Spencer was at this time cultivating an acquaintance with geometrical questions, largely because of their relation to his work as an engineer. However that may be, he appears to have considered the Civil Engineers' and Architects' Journal a fitting medium by which to make his theorem known. It relates to a property of circles inclosed within the triangles which may be drawn between the chord and arc of a circle, and is of considerable interest though it is not necessary here to be more specific. How he came upon it, it might be interesting to know; but we may readily grant that only one taking a vivid pleasure in such questions would be likely to do so.

The next thing traceable to him is a signed description of a new form of viaduct. He disowns the inception of the idea; but it is indexed as "Spencer's Tension Viaduct" nevertheless, and is dated from Derby, 1841. It is presumed Spencer made the drawings for this bridge, as in his letter it is stated that he took out the quantities himself, and he vouches for their fullness. One span of the viaduct is illustrated, and details are given, with scantlings. A description of the Fink truss is shown, of mixed iron and timber, 150-foot span; but whether this was carried out is not apparent. The drawings were prepared, as is stated in the descriptive matter, for the purposes of a Parliamentary estimate. The designer appears to have been sensible of the advantages of great depth as a matter of economy, as in this case the truss is made 40 feet deep. It would be obviously unfair to criticise the structure at this date, on the score of deficient lateral stiffness—a fault common to the bridges of that time.

In September, 1841, we have yet another contribution in the form of an article at the head of which the author is described as "Herbert Spencer, C.E." He still dates from Derby. This communication, "On the Transverse Strength of Beams," is an effort of considerable ambition, in which a theory is propounded, and mathematical analysis given, filling about five broad columns of the paper. It is clear that Spencer had applied himself industriously to the study of matters relating to his work, and was, moreover, disinclined to take accepted views on mechanics as a matter of course. The question he deals with is to this day a matter of discussion among engineers; and though his essay was written a long time ago, it is still worth looking at. Unfortunately, the reasoning is marred by defects which in great part vitiate his results.

He seems to have been fully alive to the effect of differences in the modulus of elasticity for tension and compression, and says: "The position of the neutral axis therefore depends upon the ratio between the tensive and compressive resistances of the material, and by the application of the above principle—that of equality of total fiber resistances above and below the neutral axis—with the necessary data, its situation may be found." The reasoning is somewhat troublesome to follow, but it is probable he took a delight in working it out, and felt pleased with the result. The formula for the position of the neutral axis in an H beam, which is expressed by about a dozen terms of many inches aggregate length, he admits is "somewhat forbidding in appearance," which is certainly true. Down to this point, but for one little slip in the early part of the paper, he seems to be in the main correct; but in finding, as part of his scheme, the rectangular beam of strength equivalent to the H section, he appears to go astray, and finally reaches a result which cannot be accepted, the error being of the same kind as that occurring in the earlier passages, but this time leading to a false issue. It is a little surprising that, with so much ingenuity as is evidenced in this investigation, and facility in developing algebraic expressions, Spencer should have gone on to an erroneous conclusion without discovering the fault in his method. The contribution is of interest, apart from any engineering value it may have, so far as it is correct, because it evidences a capacity for making mistakes, allied with great reasoning powers, and it may be commended to the notice of the curious. It is to be observed that Spencer in his autobiography speaks slightingly of this essay, does not reproduce it, and blames the printer for errors which spoiled his paper; but the mistakes now referred to are not mere matters of typesetting.

We next find him enlarging upon "Architectural Precedent," in a paper appearing in 1842. He remarks on the bias of the architects of his time in favor of precedent, on their acknowledging themselves already outdone by the ancients, and on their discountenancing any attempt to do better; this he attributes largely to a system of education which favored so much classical studies. The article, followed by a letter on the subject, gives evidence of his partiality for generalizing; these two communications are not in any way remarkable.

Later, in 1842, we find an illustrated description from him of an "Instrument for Calculating Velocities on Railways." He notes the inconvenience of calculating speeds from time and distance observations, when any large number have to be dealt with, and describes a contrivance admirably simple, easy of manipulation, and giving results within one-eighth of a mile per hour of the truth. It was used for some time during engine trials on the Birmingham & Gloucester Railway, and might still be used with advantage for similar purposes, though a slide-rule would serve equally well with those well accustomed to it. A feature of Herbert Spencer's ingenuity seems to have been that he was not content with the mere inception of an idea, but immediately sought to put it into practice. During the time that he was contributing these papers we know that he was engaged in positions of trust upon engineering work, upon surveys, design of works, engine trials, and supervision of contracts. Later, he was employed in Westminster as chief confidential assistant, at a high salary, to a railway engineer of large practice.

Some of his other essays, issued when he had finally taken to writing, bear also upon matters of engineering interest. The "Source of Architectural Types" is of considerable value. His remarks on the symmetry of buildings and congruity to surroundings are suggestive and will repay perusal. An article on "Railway Morals" evidences the interest he took in the finance side of engineering enterprise. Matters seem to have been in rather a bad way at this time. If Spencer is correct—and it is to be observed he had good means of knowing—both lawyers and engineers were tarred with the same brush. It is fair, however, to assume that the statements apply only to some lawyers and to some engineers. Speculations on the nature of electricity, and his well-known criticism of the metric system, are matters which, though bearing upon engineering, do not by themselves give evidence of his regard for engineering as a profession. He made excursions into so many departments of knowledge that

we might, if no better reason were available, equally well declare him to be a born lawyer or divine. He himself narrates his endeavors as an inventor, and gives an account of a partnership with a friend upon one such adventure, which came to an untimely end by the defection of his friend. It is impossible to miss the impression induced, by his own account, that he felt himself to be an engineer. He abandoned the profession not because he was, as an engineer, a failure, but rather on account of the strong bent he had in another direction; this influence coming as it did concurrently with the depression in enterprise following the railway mania, and accompanied by opportunities presenting themselves which promised to give him some facilities for the expression of his philosophical views, which were already taking shape in his mind, seem to have determined the final severance from his original calling. He would, it may reasonably be concluded, have attained to some considerable eminence had he continued in it. He possessed mathematical ability, original ideas, much ingenuity, great courage and independence, with a manner which, whatever it may have been in detail, seems to have been quite consistent with the growth of the kindliest feelings toward himself on the part of those with whom he came in touch. The confident assurance with which he would question the dictum of those older or better established than himself seems at times to have caused a little friction with his fellows and superiors. He seems never to have been in doubt; but it is probable an expressed opinion was preceded by much careful thought. As a young man he was, perhaps, one of those rather trying people who, with a little too much confidence of manner, are yet, with irritating frequency, right. He had an honest confidence in his own judgment—possibly with experience to justify him—and was so little of a pretender that this confidence was clearly apparent in his conversation.

It is probable that surveys and drawings by Spencer's own hand are still in existence; the Midland Railway Company very likely have some. The chances are that any of his drawings will show indications of his identity as the draftsman. His individuality and assertiveness were so marked that it is almost inconceivable any drawing of his would fail to bear his initials upon it somewhere, whatever his position in relation to the work may have been as a matter of responsibility.—Engineering.

PASSENGERS ON ATLANTIC LINERS.

THE return of passengers landed at New York by Atlantic liners during the past year, which has reached us this week, establishes several important records. In the first place, the total numbers of both cabin and steerage passengers are the largest in any year, and the average number per liner is greater than in any previous period. In this latter respect there has been a very steady development. Ten years ago the average number per ship was between 400 and 500, but now we are approaching 1,000, the figure for 1905 being 961. This compares with 760 in the preceding year; 830 in 1903; 733 in 1902; and 639 in 1901.

When we analyze the returns from the separate lines, we note in several cases a still more decided movement forward. Up to the beginning of the century no company could claim the credit of taking 1,000 passengers in each of their steamers. In 1901, however, the North German Lloyd stepped into this position with an average of 1,130. In 1902 they were joined by the Hamburg-American Line, and in 1903 there were seven lines with an average in excess of 1,000. In 1904, however, there were only three. For the past year we have nine lines, the Cunard Company topping the list with their Fiume service, having an average of 1,730 passengers. This is the largest recorded for any line, the highest, in 1904, being the 1,256 of the Hamburg-American Company; while in 1903 the maximum per ship was the 1,367 recorded by the North German Lloyd. The other lines with high averages for 1905 include the North German Lloyd Mediterranean service, with 1,511; the White Star Mediterranean service, with 1,479; the Hamburg-American service from Hamburg, with 1,396; the North German Lloyd Bremen service, with 1,387; the Red Star Antwerp service, with 1,336; the Navigazione Generale Italiana Mediterranean service, with 1,195; La Veloce Line, from the Mediterranean, with 1,146; and the Holland-American service, from Rotterdam, with 1,108.

Many of these high averages are due largely to emigrant or steerage traffic, but there is still a very satisfactory development in cabin traffic. This year the first place is taken by the North German Lloyd, with 393 passengers in the first and second cabins. This compares with the highest total in the previous year of 352 by the same company, while in 1903 the highest was 362. The Cunard Company come second in this respect with a total of 307, as compared with 287 and 294 in the two preceding years. Then follow the White Star with 285, the American with 246, the Hamburg-American with the same number, and the Anchor Line, from Glasgow, with 244. Twelve lines took more than 100 cabin passengers, as compared with ten in the two preceding years, so that in this respect also the increase in the size and accommodation in ships is having its effect. We give in Table I. a note of the average number of passengers per ship of the principal lines, arranged according to the number of first-class passengers taken, and indicating clearly the advance in the average per ship.

Turning now to a consideration of the totals, we give in Table II. the aggregates for several years. It will be noted that the number of cabin passengers is greater than in any previous period, being about 14 per cent above the highest previous total, that recorded in 1904, and considerably more than double the lowest total—that of 1898. It is, however, in the steerage traffic that the greatest increase is recorded. Two hundred thousand more passengers traveled by the Atlantic liners to New York, apart altogether from the number arriving at Baltimore and other ports, as compared with the previous year; while, as compared with 1903, when the total reached a very high level, owing to the rush of emigrants before the legislation against immigration became so stringent, the total shows an increase of 133,000. Last year's aggregate is enormously greater than during the nineties. The total of 961,262 passengers landed at New York is 31 per cent greater than in the previous year, about 20 per cent above the highest total previously recorded—that of 1903—and three times the number of several years in the nineties.

TABLE I.—AVERAGE NUMBER OF PASSENGERS PER SHIP OF PRINCIPAL LINES.

Line.	First Cabin.	Second Cabin.	Steerage	Total.	Total in 1904.	Total in 1903.
White Star	150	129	528	813	869	748
North German Lloyd	147	246	994	1387	1201	1367
Cunard	131	176	611	918	946	802
American	112	134	542	788	775	605
Hamburg-American	107	139	1150	1396	1256	1135
North German Lloyd (Med.)	80	136	1295	1511	893	1114
Atlantic Transport	76	...	....	76	74	98
White Star (Med.)	74	149	1256	1479	278	....
Red Star	72	143	1121	1336	971	1249
French	70	95	777	942	854	1053
Holland	69	142	897	1108	785	1005
Anchor	56	108	376	620	532	483
Hamburg-American (Med.)	44	39	735	818	548	827
Scandinavian	37	76	549	662	604	468
Spanish	36	51	575	662	417	505
Veloce	30	....	1120	1146	849	1230
Cunard (Med.)	24	39	1647	1730	1225	315
Allan-State	18	77	84	179	141	128
Empreza	18	....	319	337	139	....
Italiana	13	33	1049	1195	717	900

TABLE II.—RECORD OF ATLANTIC PASSENGER SERVICE TO NEW YORK.

Year.	Number of Passages.	Cabin.	Steerage.	Total.
1890.	....	144,178	371,593	515,771
1891.	....	150,025	445,290	595,313
1892.	....	130,991	388 436	509,477
1893.	975	121,829	364,700	486,529
1894.	879	92 561	188,164	280,725
1895.	792	96,558	258,560	355,118
1896.	852	99,223	252,350	351,573
1897.	901	90,932	192,004	282,936
1898.	812	80,586	219,651	300,237
1899.	836	107,415	303 762	411,177
1900.	838	137 852	403,491	541,343
1901.	897	128,143	438,868	567,011
1902.	922	139,848	574,276	714.124
1903.	969	161,438	643,338	804,796
1904.	967	162,389	572,798	735 187
1905.	1006	184,992	776,330	961 262

Practically all of the steamship lines have participated in the increased traffic, although the German lines have not advanced in quite the same proportion as the British-owned ships. Of the total of first-cabin passengers, one-third, or, to be exact, 33.6 per cent, traveled in German ships, as compared with 36.8 per cent in 1904 and 37.3 per cent in 1903. British-owned ships, on the other hand, took 38.6 per cent, whereas in the previous year the proportion was only 31.9 per cent, although in 1903 it was as high as 37.1 per cent, and in 1902 37.25 per cent. The other lines in the combine have not made up the difference; 69 per cent of the first cabin passengers landed at New York traveled with the combine ships, as compared with 71.6 per cent in the two preceding years. As to the second-class passengers, the same general trend is indicated; the British total is slightly improved, whereas the German total has diminished, although the proportion by the combine is higher—63 per cent against 62 per cent in 1904. In respect to steerage passengers, however, the British lines, as well as German and other companies of the combine, have failed to hold their own. Most of the purely emigrant ships from the Mediterranean have decidedly increased their proportion. As it is, 32.4 per cent of the emigrants were taken by the German lines, as compared with 34 per cent in the previous year, and 36.2 per cent in 1904, while the ships of the combine took 51.9 per cent, against 57.7 per cent and 54.5 in the previous years. Britain's quota of the steerage traffic is 23.3 per cent, as compared with 26.5 per cent in 1904, and 18.5 per cent in the previous year.

Practically all the important lines have increased their traffic, and that, too, without materially adding to the number of sailings. Table III. gives the list of lines, with the number of first, second, and steerage passengers carried by each in 1905 and 1904. It will be seen that the North German Lloyd again top the list, having taken 177,871 passengers—equal to 18.5 per cent of the total number of passengers landed at New York. The great majority of these were steerage voyagers; but the company have taken more first and second-class passengers than any of the other lines. In all 125 trips were made. The total is considerably higher than in previous years. In 1904 it was 135,547, and in 1903, 155,110. The other German line—the Hamburg-American—occupies again the second place, the total number of passengers being 139,972, of whom 116,863 were conveyed in the steerage. The total is greater than in the two preceding years, when the aggregates were 120,323 and 138,423 respectively. The number of Hamburg-American trips was eighty-seven from Hamburg and twenty-one from the Mediterranean ports. The third place is taken by the Cunard Company, and here the total is 98,419. This includes the very extensive traffic undertaken by the company from Fiume. The Cunard total is about 16,000 greater than in the previous year, a marked increase having taken place in the number of first-class passengers conveyed. The White Star Line is fourth on the list, with an aggregate of 91,435, or 9,000 more than in the previous year, the totals, of course, including the passengers by the Mediterranean service. The results of the other lines are set out in the table. It will be noted that practically all of them mark a very considerable increase, which, so far as cabin passengers are concerned, is more marked in the case of the Red Star, French, and Anchor Lines, while the American Line took 1,400 more first and 2,000 more second-class passengers, occupying, as usual, a high place in this respect.—Engineering.

TABLE III.—RETURN OF PASSENGERS LANDED AT NEW YORK BY PRINCIPAL LINES.

Line.	1905.			1904.		
	1st.	2d.	Steerage.	1st.	2d.	Steerage.
North German Lloyd	15,974	26,843	135,054	15,414	21,684	98,449
Hamburg-American	10,208	12,901	116,863	9,830	14,353	99,140
Cunard	8,704	12,328	77,387	6,575	13 249	64,027
White Star	14,618	13,328	63,489	13,130	10,942	58,260
Red Star	3.816	7.560	19,431	2,933	6.505	39,148
French	5,006	6,812	55,918	4,556	6,905	34,684
Holland-American	3,267	6,656	42,134	3,027	5,140	25,633
Anchor	2,816	8,666	38,433	1,833	6,065	28,047
Italiana	455	1,139	35,608	421	909	17,330
Veloce	768	.....	32,476	673	....	18,885
Fabre	181	....	30,694	111	....	17,257
American	5,623	6,753	27,106	4,206	4,729	28,316
Atlantic Transport	3,590	13	28	3 634	....	90
Austro-Americana	154	197	17,125	62	54	4,388
Prince	91	1	14,982	84	2	8,081
Scandinavian	923	1,004	13,728	965	1 549	19,569
Spanish	432	614	6,868	370	245	4,393
Allan-State	319	1,390	1,520	304	1,301	2,362
Empreza	55	.....	958	18	.....	409

AN AMERICAN INVENTOR AT KIMBERLEY.

IN the Century Magazine Mr. T. J. Gordon discourses interestingly of the remarkable services rendered by an American civilian, Mr. Labram, during the memorable siege of Kimberley. Judging from Mr. Gordon's account, Labram seems to be the true type of the American inventor.

Although Mr. Labram's services were known and appreciated by the authorities, it was not until the second month of the siege that the people of the town as a whole and the rank and file of the troops came to realize the versatility of his genius. From the somewhat prosaic problems of water, food, and lighting Labram suddenly turned to a work which set all Kimberley talking.

When the siege began the artillery strength of the town consisted of the Twenty-third Battery, Royal Garrison Artillery, with six seven-pound mountain guns, and a local volunteer battery of six seven-pound guns. These twelve pieces had each an effective range of about 4,000 yards; two unreliable old Cape police seven-pounders completed the list. The inadequacy of such equipment was in itself serious enough. It paralyzed the whole scheme of defense. The full gravity of the situation did not appear, however, until the beginning of November, when Col. Chamier, who commanded the artillery forces, reported that the ammunition for his guns was giving out. A moment's reflection will show that, with her cannon silenced, Kimberley's doom was accomplished. Small as her guns were, they prevented the enemy from bringing up their heavy ordnance to within 4,000 yards of the town, and they made possible a number of minor operations outside the barrier, such as reconnaissances, patrols, and the grazing of horses and mules. In fact, their presence insured a marginal area round the town essential to defense. If they went out of action, the enemy would inevitably move up their artillery and batter the place from point-blank range.

The authorities at once reduced the expenditure of ammunition; but still the supply dwindled. Apparently there was only one possible upshot. At a meeting of the staff Mr. Labram asked if he might see one of the seven-pound shells. After examining it carefully he said, "I guess I can make things like that all right." His confidence was not immediately communicated to the officers about him. They knew that the manufacture of shells is highly specialized work, and is confined to the great arsenals of the world.

On inquiry, it appeared that the only powder procurable in Kimberley was intended for blasting, and was, without special preparation, wholly unsuitable for artillery uses. Mr. Labram, however, refused to be deterred by such considerations. That afternoon he obtained a requisition from the military stores of such material as was likely to be of use in the experiment, and began work in the De Beers shops. His foundry may be said to have been the child of his own brain, for he was without even reliable handbooks to guide him. The most important part of shell manufacture is the fixing of a satisfactory fuse. Mr. Labram overcame this difficulty by invention. He designed a percussion fuse to be inserted in a hole drilled for its reception in the point of the shell. The fuse consisted of a brass body with a screw thread outside and a steel block, or plunger, working freely in an axial direction inside. The plunger, through which a small hole was bored, was pointed at the front end. In a recess in front, a percussion cap was held in position by a screwed plug.

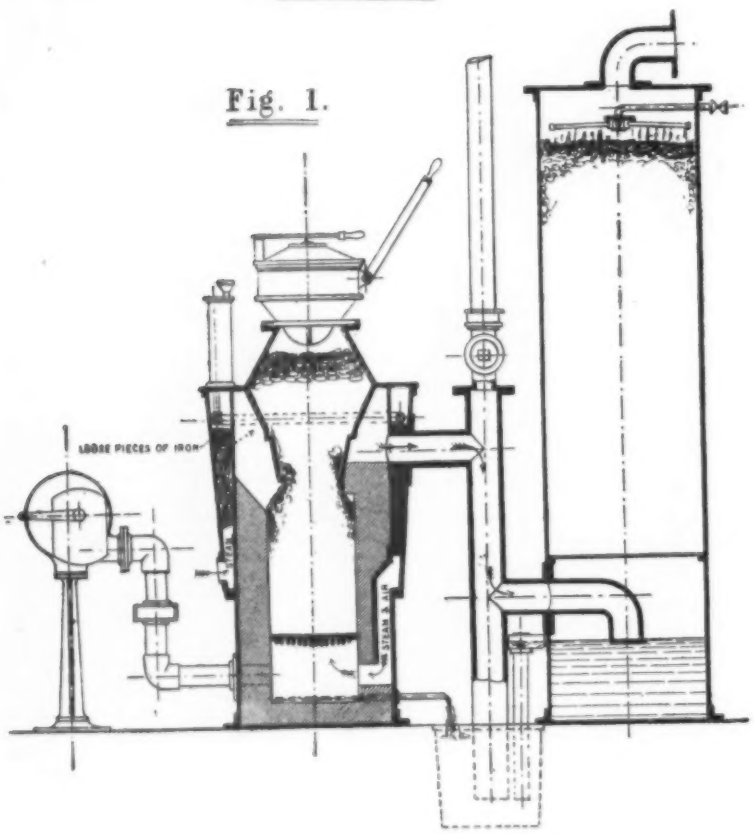
While the shell traveled forward, the plunger, being loose, remained at the back of the fuse. On a sudden stoppage, however, it shot forward and struck the percussion cap. A spark then traveled along the hole and

exploded the bursting charge of gunpowder contained in the body of the shell. To prevent the plunger from moving when the shell was handled, a light spiral spring was so placed as to require compression before the nipple could touch the cap. As an extra precaution, safety wires were provided, which had to be broken before the plunger could move. The united strength of these safety attachments was not more than sufficient to prevent premature explosion in case of accidental fall.

In practice Mr. Labram's astonishing invention proved entirely satisfactory. In an amazingly short time this man, who had scarcely seen a shell until a few days before, was supplying the artillery headquarters with between sixty and seventy projectiles every twenty-four hours—shells, moreover, of a quality which the military authorities, after the exhaustive test of over three months' continual use, pronounced "extraordinarily good."

THE "DOWSON" GAS PLANT.
SUCTION TYPE

Fig. 1.



THE "DUFF-WHITFIELD" GAS PRODUCER.

Fig. 2.

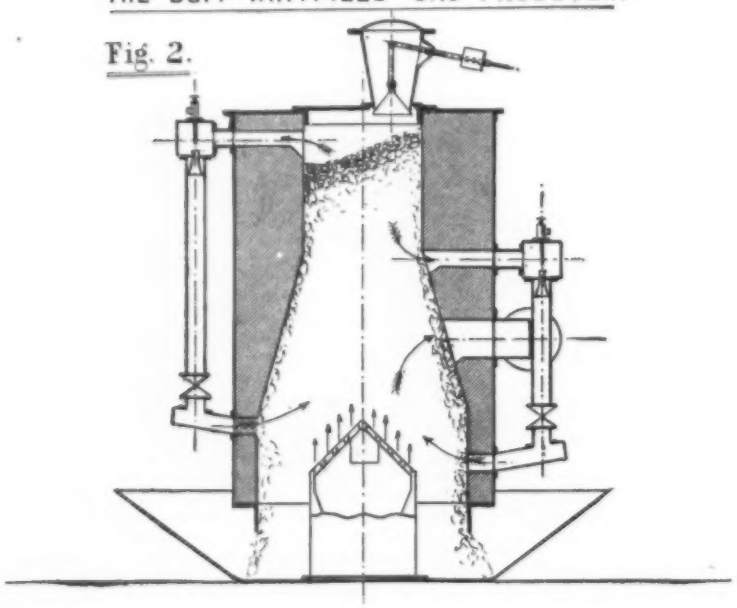


Fig. 3.

THE "BOUTILLIER" SUCTION GAS PLANT.

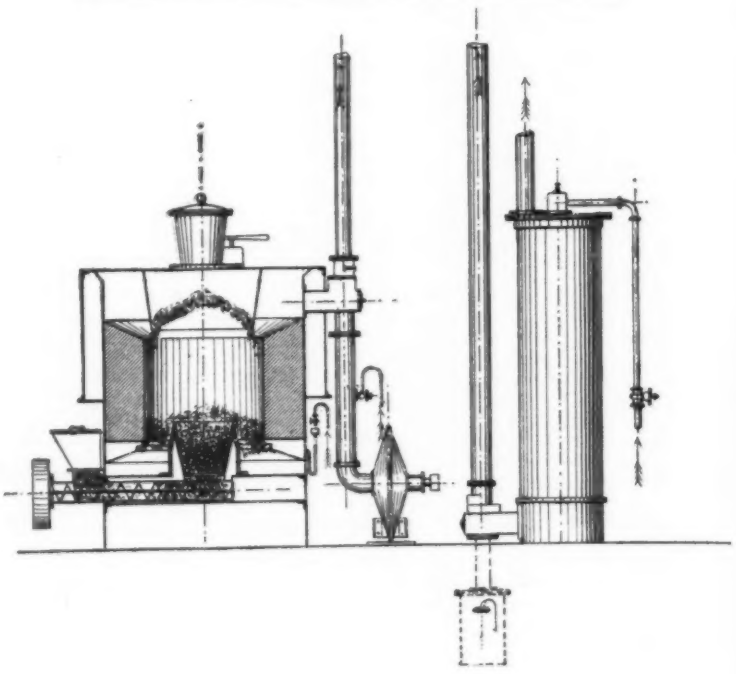
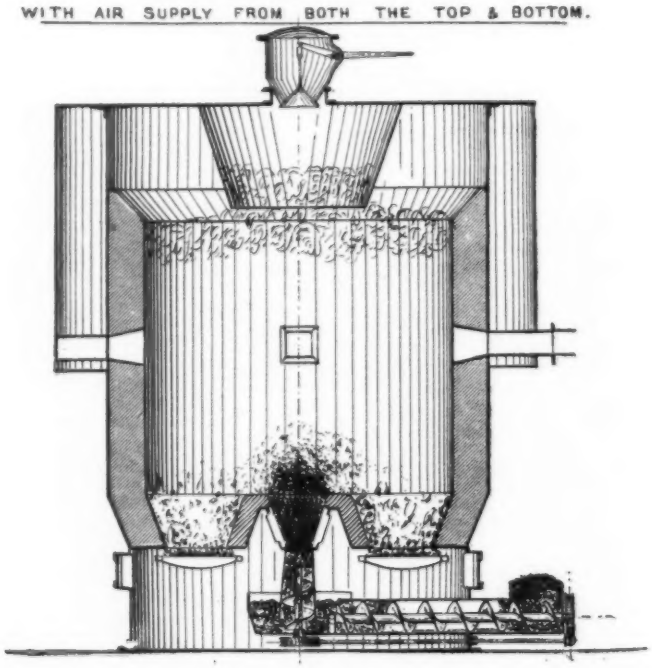


Fig. 4.

SUCTION GAS PLANT.
WITH AIR SUPPLY FROM BOTH THE TOP & BOTTOM.



GAS ENGINES FOR SHIP PROPULSION.*

By J. E. THORNYCROFT.

THE gas producer which is generally used for moderate powers works on what is known as the "suction" principle: that is to say, instead of the gas being generated by the combustion of fuel, by air and steam being forced through it under pressure, it is generated by the air being drawn through the producer, the whole of the apparatus working somewhat below atmospheric pressure. The advantage of this system is that neither a steam boiler working under pressure nor a gas container for holding the gas is required, and the further very important advantage for marine work is that there is no danger from a leakage of gas from the producer; if leakage takes place, it is from the atmosphere into the producer itself.

There are so many combined plants consisting of a gas engine working in conjunction with a suction producer at work for stationary purposes, that it might appear only very small alterations would be required in these plants to adapt them for marine propulsion; but, in addition to the great difference between almost all marine and land plants, viz., that of the quick and frequent variations of load which the smaller types of marine plants have to undergo, there are very many features which must be changed to adapt the gas engines and producer for boat work. In fact, it will be found that the principle of operation will be about the only thing which can be identical with the land plant; the details of the apparatus all having to be specially worked out for the new conditions.

The producers for moderate sized powers are usually worked with anthracite coal, and where vessels are to be used on fixed routes, and the same class of fuel can always be obtained, anthracite or coke will be found to be the most suitable for moderate powers, it being too difficult to make a satisfactory small plant to work with bituminous coal.

For larger powers, and for vessels that have to take up fuel at different ports, the producer must be capable of dealing with coal, other than anthracite, which may be of a tarry or caking character.

The design of the producer capable of successfully dealing with bituminous or caking coal is a much more difficult problem than the anthracite producer. There are, of course, very many large land installations of pressure producers working with bituminous coal, but the apparatus for extracting the tar and other by-products, as at present arranged, is far too cumbrous for marine work, and the marine producer to deal with this class of coal must be designed on entirely different lines, being arranged to consume the tar which is evaporated off from the coal in the first stages of its heating. This has been arranged in some producers by taking the gas off at a comparatively hot part of the fire, instead of at near the top of the new coal, as is usually the case with the anthracite producer; but there are plants now at work dealing successfully with bituminous caking coal, which are fed by an undertype stoker, so that the new coal is forced into the hottest part of the fire, and the tar which is driven out is at once burned.

After the gas leaves the producer, it must be first cooled, and, as there will always be a certain amount of impurity, even when anthracite is used, it has to be thoroughly cleaned. This is usually done by passing the gas through a series of vessels where it is scrubbed by its passage through layers of coke over which water is running.

It is frequently arranged that the cooling of the gas is effected by passing it over a water-containing vessel, which acts as a generator for the steam required by the producer; but there are disadvantages in this method where the producer is not working at a uniform load, as the steam will not be generated until the producer has been working some time, and will

* Read before Institution of Naval Architects.

continue when the engine has been stopped, and when it is not required, and so cool the fire, causing the gas to be poor when the engine is again started, after the temporary stoppage has taken place.

The large space occupied by the ordinary coke scrubber prohibits their use for marine work, and to meet this difficulty Herr Capitaine has arranged his plant to clean the gas after it has been cooled, by the introduction of a very fine spray of water, which mixes with the small particles of dust and other impurities in the gas, and forms a sort of fog; the gas in this state is passed into a centrifugal apparatus, having a peripheral speed of 160 feet a second, which throws out the moisture and impurities, leaving a clean dry gas to be drawn out by the engine.

The composition of this gas may be taken to be about as follows:

Carbon dioxide	6 per cent
Carbon monoxide	25 per cent
CH_4 methane	1 per cent
Hydrogen	14 per cent
Nitrogen	54 per cent

It will be realized that the size of the producer for a given power is comparatively small when it is known that the area of the fire grate necessary is only 0.05 square foot per horse-power, whereas the average for an ordinary natural-draft steam boiler, burning 15 pounds coal per square foot grate area, would be 0.2 square foot per horse-power.

The depth of the fire will vary considerably with different qualities of coal used, but will not be usually more than two to three times the diameter of the fire grate.

DESIGNS OF DIFFERENT TYPES OF PRODUCERS.

Fig. 1 shows Messrs. Dowson's arrangement of suction producer designed for anthracite coal. The majority of the smaller suction producers will be found to closely resemble this type. A fire-brick-lined steel casing is fitted with fire bars and a closed ashpit, and in the upper part of the casing a conical hopper is placed with the usual valves for opening and closing to admit fresh charges of fuel. The gases come off the fuel at the base of the conical hopper, and pass through a steam-generating pipe or vessel, and then away to the cooler and scrubber. The producer is fitted with an outer casing in which the air is heated, and mixes with the steam on its way to the ashpit.

Fig. 2 shows the Duff-Whitfield producer arranged for working with bituminous fuel. In this producer, the tarry products which are evaporated off from the new coal are caused to pass through the hottest part of the fire, and so are consumed before the gas passes away to the cooler.

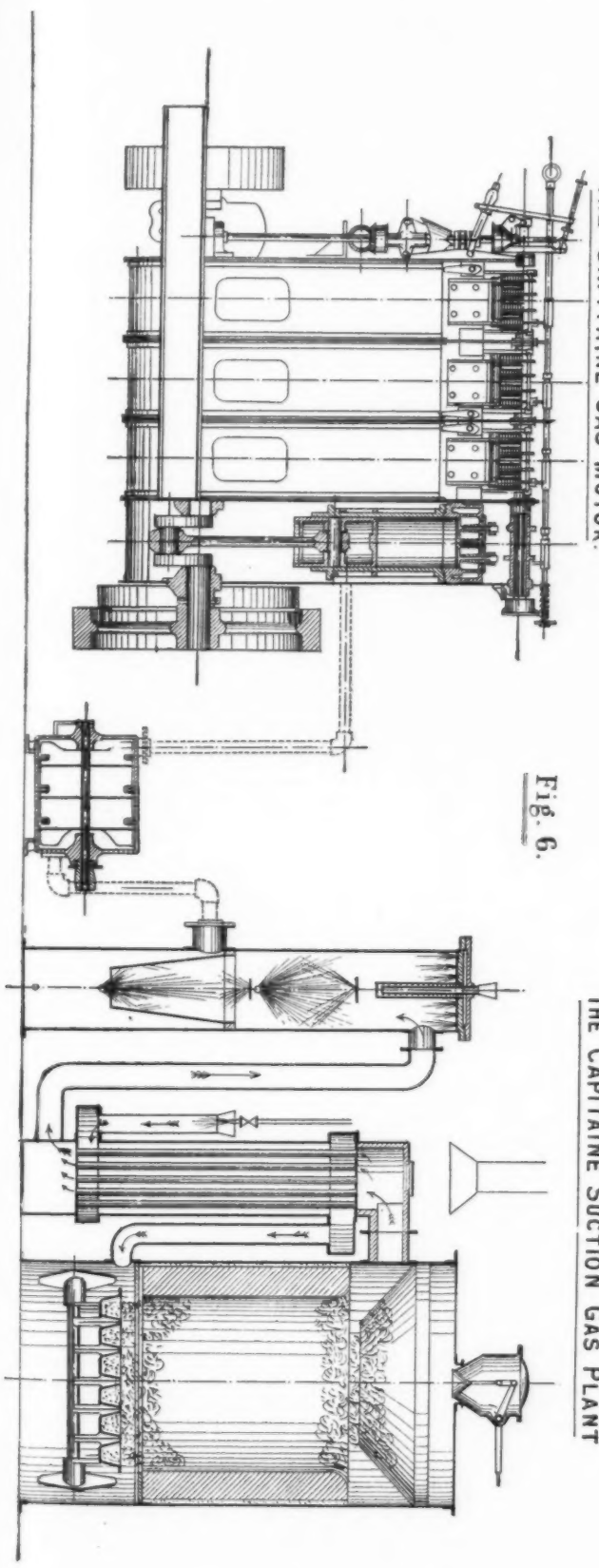
Fig. 3 shows the "Boutillier" producer arranged for working with bituminous fuel, in which the fuel is supplied by an undertype stoker to the hottest part of the fire, so that the tar is at once decomposed, and cannot pass away with the gas. The principle upon which this producer works seems to be one of the best adapted for marine work.

The "Jan" producer consists of a series of producers which are arranged to work in sequence, the gases of one which has been newly charged passing through another which has been at work some time, so that there are always some of the producers supplying tarry gas, the tar being consumed by one of the other producers in the later stages of the series.

The heat losses in the producer itself are very small, as the whole plant can be so thoroughly lagged that practically there need only be heat passing away with the gas that is being generated. The loss from this cause may be very much reduced by using it to heat the air supplied to the producer.

The heat efficiency as given by Messrs. Dowson for their suction plant is 90 per cent. As the result of a great many tests, the late Mr. Bryan Donkin gave the average heat efficiency of steam boilers at 66.7 per cent.

To start up the Capitaine producer, a fire is lighted on the bars, and the producer is then filled with fuel, air being either drawn or blown through it by a hand or power-driven fan. For a producer of about 50 to 100 horse-power, twenty to thirty minutes should be



THE "CAPITAINE" GAS MOTOR.

Fig. 6.

THE "CAPITAINE" SUCTION GAS PLANT

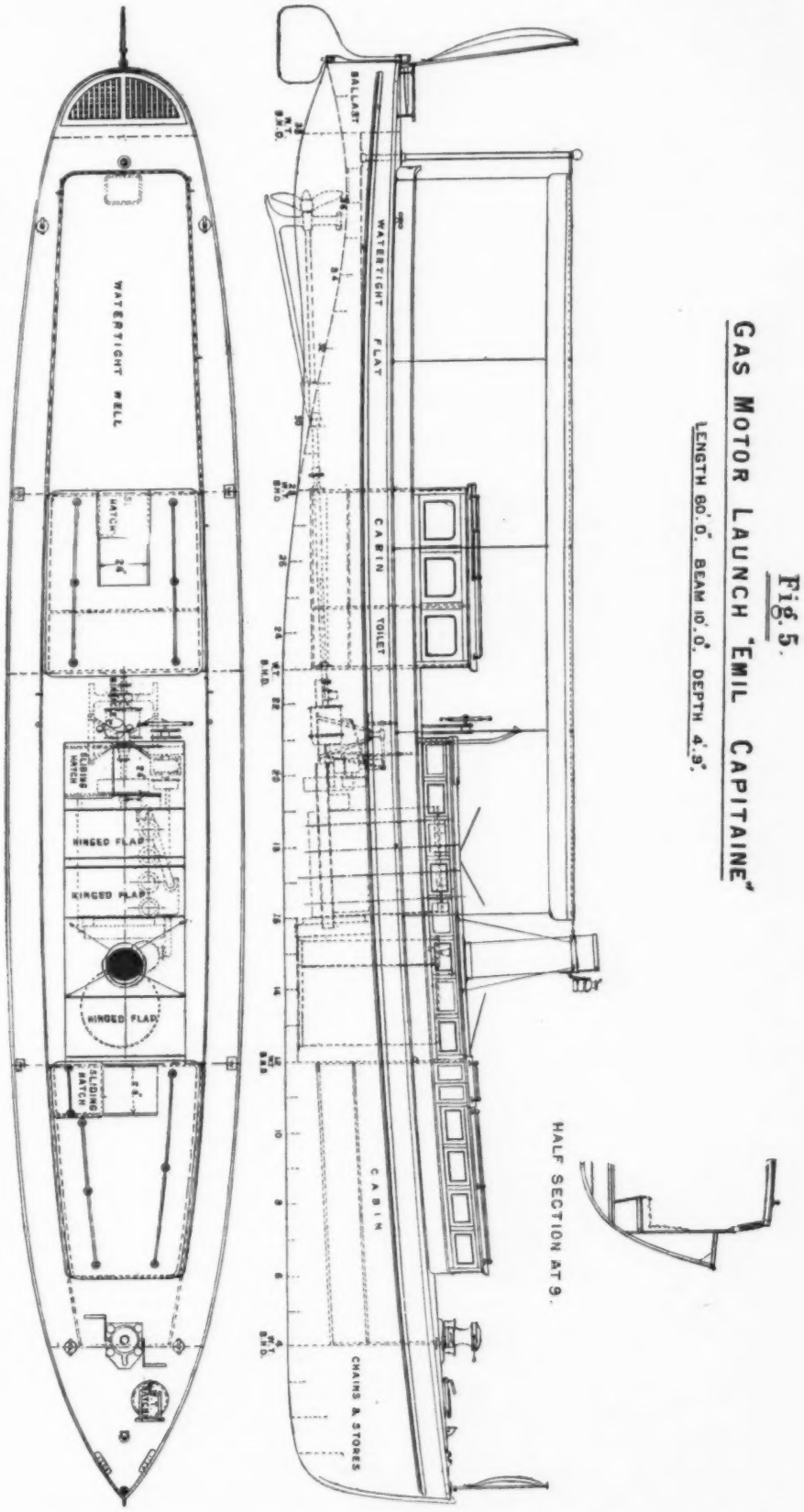


Fig. 5.

GAS MOTOR LAUNCH "EMIL CAPITAINE"

LENGTH 60'.0". BEAM 10'.0". DEPTH 4'.9".

sufficient to give good gas. This can be ascertained by lighting the gas which is being given off, and seeing that it continues to burn with the right sort of flame. The gas first produced will have very little hydrogen in it, and will not be very powerful, and requires the steam generator to come into operation. The steam which is added to the air entering the producer strengthens the gas by the water being decomposed, and gives the percentage of hydrogen which is shown in the analysis above referred to. The gas produced in this way is of a comparatively slow-burning nature, and may be described as poor gas, to distinguish it from town gas, and some of the other gases generated by pressure producers which have a larger proportion of hydrogen, such as water gas.

There is an advantage in this slow-burning gas, as it enables the engine to work with a high compression, thus giving a larger range of expansion, and consequently a high economy. The slow-burning nature also avoids the violent shocks which occur when more powerful gases are used, and so a smooth-running engine is obtained. The producer once being set to work will continue to generate gas in large or moderate quantities as the engine requires it and sucks it from the producer. The producer will probably be given the best gas at somewhat near its full capacity, but will continue to give good gas down to a small proportion of full load. At very light loads it is difficult to keep the fire hot enough to produce good gas, and special means have to be adopted to keep the producer hot enough on these occasions.

Having now generally described the producer, the difficulties and advantages of adapting the gas engine itself to marine work will be considered.

The one great disadvantage of the internal combustion engine is the necessity of setting the engine in motion before it will run automatically. For powers less than 200 horse-power, it is preferable to employ a reversing gear, keeping the engine always running in the same direction, or to use a reversing propeller. Compressed air is being employed for starting up large engines, and when once the engine is fitted in this way, the valve gear for running the engine in either direction does not amount to very much.

For moderate powers, a single acting engine with a trunk piston is found most convenient, as the piston does not require to be water-cooled, until one as much as about 2 feet in diameter is employed. A single cylinder of 20 inches diameter and 2-foot stroke, running at 120 revolutions per minute, will give about 100 horse-power, taking the average working pressure at about 80, which is less than the figure often obtained.

The same sized cylinder, working as a double-acting cylinder, would, of course, double the horse-power; but, besides the additional valves, which must be an exact duplicate of those required for a single-acting engine, there is the complication of the water-cooled piston and rod. This at first sight will appear somewhat serious to the marine engineer, but when the very large number of engines of this design which are working on land is considered—the regularity with which they are run, and the little attention they require—it will be agreed that there does not seem any reason why they should not meet with success at sea.

For small plants of from 100 to 200 horse-power, a small auxiliary internal combustion motor, driven by oil or some other fuel, is found most convenient for blowing up the producer, for starting it, and also for starting the main engine.

For larger powers fitted to vessels where steam capstans and steering gear are fitted, it is thought that the best plan will be to employ an auxiliary boiler, which can be heated by the gas when the whole plant is at work, and can be used independently to drive the various auxiliary and starting engines when the producer is not alight.

The average heat efficiency of steam boilers is taken at about 66 per cent.

Prof. Capper has stated that the theoretical maximum thermal efficiency of the steam engine is only 30 per cent, and only from 5 per cent to 20 per cent of the heat generated is ever turned into useful work. In the case of the gas engine, the theoretical efficiency is about 80 per cent, and in practice 25 per cent to 30 per cent of heat developed in the cylinder is turned into useful work.

For vessels fitted with small-powered compound-condensing engines of less than 100 horse-power, the fuel consumption will be from 2 to 3 pounds per I. H. P. For gas plants of this power the fuel consumption will be less than 1 pound per I. H. P. For larger powers of not less than 500 horse-power the economy will not be quite so marked, but will be about as follows:

Steam plant, say, 1.6 lb. per I. H. P.
Gas plant, say, 0.8 lb. per I. H. P.

At this figure of one-half, the gas plant should be well worthy of adoption from an economical point of view, as, in other words, the same coal will do double the work.

The stoking and the cleaning of the fire of the producer are much less than would be required for a steam boiler of the same power, the stoking being practically automatic, and practically the whole fuel other than the clinkers is consumed.

From the plants made, and from designs that have been got out for moderate powers, it would appear that the space occupied by the gas generator and engine is about the same as the steam plant; but for large powers, where a double-acting gas engine is employed, the weight will be considerably less, as the engine will be about the same weight as the steam engine, and the producer will be very much lighter than the boiler.

The type of engine adopted by Herr Capitaine for his small powers is built with a plate frame, no casting being employed in the engine other than the cylinder itself. A light engine is thus obtained, and there is no danger of breakage resulting from the very high pressures employed. Figs. 5 and 6 show the engine fitted to the vessel which ran in the reliability trials in the Solent last summer, which was named "Emil Capitaine," after the inventor of the system.

The official report of the trials shows that this boat of 16 tons displacement ran at an average speed of 10 miles per hour for 10 hours, on a consumption of 412 pounds of anthracite coal. This consumption also includes the fuel which was consumed by the producer during the previous 12 hours, when it was not in active operation, but simply smoldering and keeping itself alight, the producer having been filled the night before the trial. The amount of fuel consumed in this way is very little, but should be taken into account when making a consumption trial.

Several tugs, boats, and other vessels have been fitted with similar engines to the one illustrated, and are at the present time running on the Continent on the inland waterways; but, as far as is known, the "Emil Capitaine" was the first vessel fitted with a gas engine and producer to run in the open sea.

For the purpose of comparison, tests were made on November 8, 1904, with the "Gastug No. 1" and "Elfriede," a steam tug of very nearly the same dimensions and power. The "Gastug No. 1" is 44 feet 3 inches long by 10 feet 6 inches beam, and is fitted with one of the four-cylinder 70-horse-power suction gas plants. The "Elfriede" is 47 feet long by 12 feet beam, and is fitted with a triple-expansion steam engine developing 75 horse-power. At the towing meter the "Gastug No. 1" attained a maximum pull of 2,140 pounds, and the "Elfriede" a maximum of 2,020 pounds. A run from Hamburg to Kiel and back was made by these two boats, during very stormy weather, at a maintained speed of 8½ knots. The consumption of fuel was measured for a period of 10 hours, and was as follows: For the "Gastug No. 1," 530 pounds German anthracite; for the "Elfriede," 1,820 pounds steam coal. This shows an economy of 1 to 3.44 in favor of the gas plant.

Messrs. Deutz, the well-known gas engine builders of Cologne, have fitted one of the large Rhine barges with two of their two-cylinder land type engines and producers. The vessel is of 200 tons carrying capacity, and is said to have given satisfactory results, running on the Rhine between Rotterdam and Cologne.

(To be continued.)

CONTEMPORARY ELECTRICAL SCIENCE.*

A NEW CEMENT.—B. Walter reports upon a new cement brought out by the New York & Hamburg India-rubber Company under the somewhat awkward name of picein, conferred upon it on account of its pitch-black color. It melts at 80 deg., and the apparatus to be joined need, therefore, not be heated as much as in the case of sealing wax. It possesses, however, sufficient toughness at ordinary temperatures to give a good joint. It is insoluble in water and nearly insoluble in alcohol, but easily soluble in benzine and turpentine. The author does not state the composition of the substance.—B. Walter, Annalen der Physik, No. 14, 1905.

MAGNETO-OPTIC EFFECTS.—Magnetic rotatory dispersion, or the dependence of the Faraday and Kerr effects upon wave-length, has hitherto been studied almost exclusively in the visible spectrum. L. R. Ingersoll has now taken some measurements in the infra-red spectrum, in order to test the validity of the formulæ put forward for rotatory dispersion. He used carbon bisulphide for the Faraday effect on account of its transparency for heat waves, and worked with wave-lengths up to 4,300 $\mu\mu$. The Faraday effect in the infra-red is correctly represented by a formula which takes account of the absorption band beyond 8,000 $\mu\mu$, showing that an infra-red absorption band may effect the rotatory dispersion, much as it does ordinary dispersion, over a considerable range of spectrum. As regards the Kerr effect, for which the author used two mirrors of the substance to be examined, the dispersion-curves as now completed show a marked resemblance to a typical dispersion curve in the region of an absorption band, thus indicating the existence in metals of something analogous to a region of resonance-absorption, extending over the visible spectrum. The particular cases of nickel and magnetite are notable, for the rotation appears to vanish for a particular wave-length in each case, and then change in sign. But one of the author's most interesting results is that in Heusler's magnetic alloy the Kerr effect is almost imperceptible. This is the only case in which the alloy fails to exhibit its magnetic properties, and the fact may do something toward elucidating the nature of the Kerr effect. Although the results do not allow of definite conclusions as to whether the hypothesis of molecular currents, or of the Hall effect, should be accepted in explaining magnetic rotation, the indications are that the latter theory holds for carbon bisulphide. It presents a case analogous to that of sodium vapor. But the curves of the magnetic metals require the former explanation, although the reversal of nickel might perhaps be considered as evidence for the Hall effect.—L. R. Ingersoll, Philosophical Magazine, January, 1906.

MOLECULAR LAYERS OF LEAD SUPEROXIDE.—J. Koenigsberger and W. J. Mueller maintained last year that any molecular layer producing the passivity of iron must be less than one-tenth of the wave-length of the light in thickness. They now go much further, and maintain that such a layer does not exist at all, for, if it did, it would have to be at least one molecule in thickness, and layers of molecular thickness are easily discoverable by optical methods. The authors precipitated lead superoxide from a nearly neutral solution of acetate by a current of 62 micro-amperes acting for 10 seconds, the cathode being a plate of platinum-iridium alloy. By observing the interference colors with layers of greater thickness they made sure that Faraday's laws of electrolysis hold good for the thinnest layers, and so they are in a position to maintain that the quantity of PbO_2 deposited was 7.8×10^{-4} milligrammes. Moreover, the layer was continuous, as proved by observing the reflection by Toepler's method. The electrolytic forces were stronger than the forces of crystallization. Since the density is 9.3, the layer had a thickness of 0.84 $\mu\mu$, or 1/500 of the wave-length of blue light. On depositing more PbO_2, the reflecting power gradually fell from 61 per cent, that of the platinum iridium, to 15 per cent, that of the superoxide, which it reached at about 1/20 millimeter. By measuring the E.M.F. of thin layers of PbO_2, the authors found that they do not acquire their full E.M.F. with thicknesses less than 4.2 $\mu\mu$, so that electrolytically active layers are easily perceived. The thickness 0.84 $\mu\mu$ is, according to the mean of the best calculations hitherto made, equal to the diameter of the molecule of PbO_2, or perhaps double that diameter. It agrees with Stefan's value deduced from diffusion by the kinetic theory of gases.—Koenigsberger and Mueller, Physikalische Zeitschrift, December 1, 1905.

ELECTRON THEORY OF THE COHERER.—In a lengthy paper on contact resistances, A. Blanc reviews the theories hitherto advanced to account for the action of the coherer. Lodge's welding theory is best supported by experiments, but these have usually been made with currents much stronger than the coherer is capable of indicating, and the welding produced by these feeble currents, if it takes place, must remain imperceptible. Branly's assumption of a "modification of the dielectric" is discountenanced by the fact that the dielectric seems to be of no account. The prevalence of the ionization idea might lead one to suggest that the gaseous or liquid medium might be ionized, but here again the author's own experiments, made with Röntgen, radium and ultra-violet rays, fail to show the slightest effect upon the resistance of a contact, either before or after coherence. The heat rays from an Auer burner affect the resistance in an irregular and uncertain manner, but this effect is simply the well-known action of heat. The only agency which had a decided and well-determined effect upon contact resistance was found to be pressure. Meyer has studied this action, with heavy pressures. But these are not practically as interesting as lighter pressures. The author produced these between a steel plane and a hemisphere, the latter being attached to a lever bearing at its end an armature attracted by an electromagnet, counterbalanced by a spring. Very light pressures could thus be applied without shock. On increasing the pressure, the resistance diminishes very rapidly at first, and then more and more slowly. On releasing the pressure, the resistance never becomes as high as before, the pressure having increased the adherence. The marked influence of pressure suggests to the author a theory in which diffusion plays the main part. Besides gaseous and liquid diffusion, there is also a diffusion of solids in mutual contact, as shown by Barus, Spring, and others. A pressure induces this diffusion, and its result is to assimilate the surface layers of the metal to the interior of the metal. In coherence, the pressure is produced by the electric field which induces changes of opposite kinds on the surfaces of two grains facing each other. Now, the interior of a metal contains more free electrons than do the surface layers. The effect of diffusion is, therefore, to give the latter a higher conductivity. The positive ions of the metal would also take part in the diffusion, and the elevation of temperature may aid the transference of ions from one metallic grain to another.—A. Blanc, Journal de Physique, November, 1905.

* Compiled by E. E. Fournier d'Albe in the Electrician.

ARTIFICIAL FUEL.

AT a meeting of the Engineers' Society of Aix-la-Chapelle some time ago it was stated by Ney that a mixture proposed in Belgium of 80 pounds garden-mold and 20 pounds slack coal over which a solution of one pound soda or common salt in water was poured, made an excellent fuel. The same quantity of coal which under ordinary conditions would burn for half an hour would, if so treated, last for an hour. This retarding action, however, constituted the entire advantage of the fuel. The explanation was that by vitrifying the earthy constituents, the soda formed a slag under which the fire was maintained for a considerable time. There was of course no question of any direct action of the soda on the process of combustion. R. Hasenclever took the opportunity of drawing attention to the large amount of combustible matter present in many earths. He stated that he had ascertained that dirt collected from the streets of Stolberg near Aix-la-Chapelle contained no less than 20 to 21 per cent of combustible constituents, whereas the dirt from the Römerstrasse in Aix-la-Chapelle contained only 6 per cent. Consequently the selection of the earth was a matter of considerable importance. Many cavities filled up with peat are to be met with in the vicinity of Hasselt in Belgium, where the above-mentioned artificial fuel was invented. The latter is therefore useless in localities where this earth is not to be found. As was expected, the mixture proved quite impracticable for heating boilers.

Artificial Fuel.—A fuel consisting of a mixture of 95 per cent of coal dust, 5 per cent of clay and a bind-

ing material made of rye-flour and slaked lime and subsequently soaked in paraffin residue dissolved in benzine to protect it against the action of the atmosphere, is prepared by Loiseau in pieces of the size of a hen's egg. The clay is dried on iron plates over a movable furnace and ground. Then by means of a special contrivance, which measures off the requisite quantity of each ingredient, it is thrown with sifted coal dust into a receiver, in which the mass is mixed with the binding material trickling into it. The mass is then kneaded in a second large iron bucket by iron rollers with geared teeth and passed into the hopper of the press. Eight hundred and seventy large and fifty-six small molds are hollowed out in the two rollers of the press, each of the latter being 75 centimeters thick. When the rollers revolve and the molds come together, the soft mass is pressed into them and falls out in oval lumps on to a revolving belt of wire netting. The large pieces weigh 75, the small 15 grammes. They are dried by being passed five times through the length of a furnace (250 deg. C.) on revolving wire netting and then drop on to another belt provided with wire rails which carries them through a bath of paraffin refuse or residue and benzine. The highly volatile benzine is distilled off in an evaporator and the briquettes are then ready for use. The apparatus turns out 150 tons of briquettes daily. They are 20 marks a ton cheaper than ordinary coal.

Brown Coal Briquettes.—A briquette manufactory was established in 1876 at the Frielendorf brown (soft) coal mine in the district of Cassel. The following are the successive stages of manufacture. The coals are first raised in a shaft from the gallery sole of the open working by steam power in five-hectoliter trucks to the pit's mouth, whence the trucks are transported over a covered tramway, on one side to the hoppers of the boiler furnaces, on the other to those of the sorting rollers and emptied. A short transporting feeder drives the coal, intended either for dressing or compressing, into the assorting drum, which allows all pieces larger than 7 millimeters to fall, partly through the large holes at the back, partly over the end on to the pair of rollers underneath. The heap of coal crushed into pieces not larger than 7 millimeters passes, along with the coal dust falling through the narrower part of the screen, into a horizontal trough with a feeder, which carries the fine coal to an elevator. The latter raises the coal a distance of 2.5 meters to a horizontal transporting trough provided with a feeder and passing over the drying furnace, which it supplies with the requisite quantity of damp coal dust. After the latter has passed through one of the four automatically working divisions of the furnace, and has left the discharging apparatus, the dried coal is raised by means of an elevator with a casing of sheet metal to the level of the feeding hopper for the two presses, through which it is made to fall into the presses by the feed regulating slide and emerges in the form of briquettes. The latter are pressed by the machine in a wooden trough as a coherent stream and stacked in the store room unless the blocks are shipped directly from the trough-channel. The two presses do not differ materially in construction from other briquette machines which have been in operation lately and which have proved satisfactory. Each consists essentially of a horizontal 30 H. P. engine with a press-ram and a press-head, the latter connected with the base plate by strong iron attachments. The head is a cast-iron cube into which the feed mouthpiece is inserted. A chamber 1.6 meters long passes through it and contains the cast steel casing consisting of an upper and lower wedge and two side wedges, within which the ram or stamper moves and compresses the coal. A wrought iron tongue, inserted in a thick staff and resting on the upper wedge, and the front of which is pressed by a screw with a communicator, closes the chamber at the top and serves further to regulate the pressure and the friction in the press-frame. The coal already in the chamber and pressed into "plugs" as they are called, provides the resistance for the next plug. On each side of the block are hollow cheeks through which hot steam pours and warms the block. The compressed coal is taken from the mouth of the press in the form of a continuous stream, as already stated, into a wooden trough immediately under the mouth and is then put outside the building either into trucks standing in readiness to receive it, or into the store house, the machine pushing the line forward a distance of 20 to 40 meters without noticeable overloading. One great advantage of the Frielendorf over the well-known tray or plate apparatus evidently lies in the fact that it contains no moving parts of machinery, which in the latter necessitate various stoppages and repairs, besides causing a considerable amount of dust and involving danger of explosions.

Briquettes Made of Brown Coal Coke and Peat.—F. Mathey states that briquettes can also be made of brown (soft) coal coke and peat, but these require the addition of a larger quantity of saltpeter than charcoal. The latter, obtained from various factories, contained from 2 to 4.5 per cent of potassium nitrate. As a binding agent, gum arabic waste is used by the Chemnitzer Fabrik, rye flour by Knorr of Weissenfels, dextrine by others. The added quantities of gum arabic, dextrine, and rye flour are 4 per cent, 4 to 8 per cent, and 4 to 8 per cent respectively. Gluten, a waste product from starch manufactories, is preferable to rye flour.

Practical Experiences Gained in the Manufacture of Briquettes.—At a meeting of the Association of German Engineers for the district of Aix-la-Chapelle, Hilt made some observations on the briquette-making industry which had grown up in that neighborhood. He pointed out that this branch of industry could only thrive in places where slack coal could be obtained at a quarter of the cost of lump coal. In the case of caking coal dust, coking is sufficient and most profitable. For making briquettes out of non-caking coal dust, the following binding agents are employed: (a) mineral; such as clay, loam, gypsum, cement, and lime; the resulting coke is of course rich in ashes and very firm; (b) carbonaceous; such as glue, starch, tar and pitch. The briquettes obtained are impervious to the action of the atmosphere, can be easily transported or stored without crumbling, and have a heating effect similar to that of lump coal. The briquettes prepared with mineral substances are exclusively used for household purposes and are not adapted for boiler fuel, whereas those prepared with the aid of organic matter can be used for the latter purpose without excessive development of smoke with a good flue and proper attention. The somewhat slow combustion of these briquettes can be remedied by higher stacking, breaking up into smaller pieces and more frequent stoking. The briquettes are made by mixing the coal and cementing or binding material in definite proportions in a suitable apparatus provided with a mechanical stirrer, in which the mass is rendered soft by introducing hot air or heated steam and afterward molded under high pressure into blocks either in closed frames or in an apparatus similar to the well-known brick presses.

Drying apparatus for briquettes are variously constructed, but most of them add considerably to the cost of the product. We will describe the cheaper drying apparatus made by A. Wilcke.

On a solid foundation, 3.25 square meters in extent, in which are two conduits for the admission and discharge of the heating gases, two walls with flues, each one meter in thickness, are built at a distance of one meter from each other. Two stories or floors, each consisting of two iron plates, are built in between these walls; the short ends of each are closed by plates so that the fire gases passed through the flues can heat the plates. For if the flues are connected with a furnace, they conduct the fire gases to the second story, through which they pass, then to the third story, and so on, till they are drawn off to the snore-hole, finally escaping through the furnace chimney. If eight such floors, each 3 meters in length, are built one above the other, the fire gases can give off as much of their heat through a length of eight meters to the iron plates with which they are brought in contact as is compatible with the production of an adequate draft up the chimney. The gable ends of the iron floors are protected in a suitable manner from cooling. The floors are made to project alternately, so that the projecting floor can catch the coal falling from the floor above it. Movable shutters are likewise fitted to shut off the open spaces to the outside between the floors. The upper plate of each floor is surrounded on three sides by a curb; from the open side the coals are dumped on to the next floor. In order, as we have said, that the coal from floor 1 may reach floor 2, the narrow end of the latter with its curb is made to project a distance of 250 millimeters beyond floor 1. If now a contrivance is used for conveying the coal which has been dumped through the hopper upon floor 1 from the plate of floor 1 to that of floor 2, and if the transportation is so regulated that on arrival at the hopper the coal is heated to about 60 deg. C., the latter will be thoroughly adapted for the manufacture of briquettes.

The transporting of the coals over the plates is effected by means of a grating provided with shovels and moved by machinery. Two I shaped rails are fastened by two cross-pieces and two cross-rails; the lower flat side of the grating is provided with rake-shaped plates at distances of 100 millimeters from each other and the grating is connected by switch-rods with cranks turning on the shafts. When a revolving motion is communicated to the shafts by the cranks, the grating is pushed backward and forward along the plates. No advancing of the coal lying on the plates would, however, result from this motion of the grating; this can only occur when during the backward movement the grating glides over the coal without touching it. Cams are therefore attached to the shafts, the effect of which is to raise the grating on its return journey. This raising is, of course, gradual at first; the coal, which has been plowed into furrows during the transport, is again made even by the shovels; this entails a systematic stirring, essential for the uniform drying of the coal which is to be made into briquettes. In order that the grating may be kept in the highest position till the end of its return movement, it is made to run on a small wheel by means of a flap and maintained in this position; as soon as the return movement is complete the grating falls and the operation of transporting begins again.

To obviate the scraping of the shovels against the plates during the transportation, the rails run on little wheels and supporting arches are placed in the floors to prevent warping of the plates. The gratings in the middle also run on three small wheels.

As the coal is poured in a continuous stream through the hopper on to floor 1, it is carried forward by the starting of the grating. When the latter begins its backward movement, a slide plate closes up the hopper and the supply of coal is stopped as long as the backward movement continues, otherwise too much coal would accumulate in the hopper and would be thrown over the edge. The coal is gradually carried over floor 1 and falls on to floor 2, and so on till it reaches the press, to which it is conveyed by elevators or feeders. During the transport it is exposed to the heat radiating from the plates, which, as we have said, are prevented by dampers from parting with their heat too rapidly, and the fresh coal receives the greatest amount of heat, since the heating gases are conducted into the apparatus from above.

An apparatus for pressing coal bricks from small coal has been constructed by Clayton.

A horizontal plate, with press-molds corresponding in size to the briquettes, is fixed between two cast-iron upright posts. The coal, properly prepared beforehand, is passed from the mixing cylinder into a box moving along this plate. A backward and forward motion is imparted to the box from the cross-head by means of bent levers. The bricks are pressed from two opposite sides. The impulse to the lower pressing piston is given by cams fixed to the wrought iron shaft in the frame. The movement of the piston pressing from above is imparted by the staff by means of cranks and powerful connecting rods suspended from the cross-head introduced into the frame-posts. The upper pistons are provided with powerful springs to prevent excessive pressure on the parts of the machinery.

As soon as the molds are filled, the upper and lower pistons come into operation simultaneously and press the coal dust into hard bricks. When the upper pistons rise, the lower pistons follow in the same direction, forcing the completed bricks out of the molds on to the level of the table. The box arrives with fresh material for pressing and removes the bricks.

The lower pistons, which also serve the purpose of lubricating the molds in the usual manner, are made to descend by means of cams fixed to the shaft.

A 2-horse-power engine suffices for driving a press supplying 10,000 bricks per day, each brick weighing about 5 pounds. The space required is inconsiderable, a surface 5 feet by 4 with a height of 6 feet being sufficient.

Finally we may mention a machine for making artificial fuel out of anthracite coal dust constructed by Loiseau.

The dust is moistened on a platform and pushed into the hopper of a stationary cylinder in which a shaft rotates. Six radial diaphragms are fixed to this shaft, dividing the interior of the cylinder into six equal compartments. These compartments are filled with the dust which is driven by the revolving movement communicated to the diaphragms toward a hole opening downward through which it falls. Another smaller hopper close to the first receives the clay, previously dried and ground. The latter is passed through a smaller cylinder likewise provided with rotating diaphragms and is discharged into the same trough as the coal dust, with which it mixes.

The space between the diaphragms of the clay cylinder is calculated for regularly receiving and discharging 5 per cent of clay, the larger cylinder supplying 95 per cent of coal dust. While the mixture of coal and clay falls under the chain elevator it is sprinkled with lime milk, raised by the elevator when moist and discharged into the hopper of the conveyor. An Archimedean screw revolving in this conveyor drives the material into the mixing apparatus, where it is quickly worked up into a plastic mass by seven vertical shafts, in each of which four toothed arms are screwed. These arms cross in all directions and thoroughly mix the clay and dust. The mass falls through openings in the bottom of the mixer and is carried by a trough into the press. There it is forced by a series of knives fixed to the central shaft and by a propeller through an opening in the bottom between two rollers having a number of oval molds. These rollers, turning in opposite directions, receive the mass from the press above in the form of a coherent band and mold it into oval lumps. These are carried forward by an endless belt of wire netting and passed into the hopper over the drying channel.

The drying tunnel is heated by two furnaces, one at each end. It contains five endless belts of wire netting arranged one above the other and revolving in opposite directions round rollers placed at each end of the tunnel. They are provided with a contrivance for preventing the coal from falling out. The pieces of compressed coal fall on to the top belt and are conveyed by it through the entire length of the tunnel; they then slide into a trough which carries them to the second belt. The latter carries the coal in the opposite direction through the tunnel to a second trough, along which they are conveyed to the third belt under the second, by which they are again carried forward and so on. The last belt conveys the coal out of the tunnel and empties it into a bucket of the elevator, by which it is raised and again transferred to an endless belt. The latter passes through an open receiver which is constantly kept supplied and filled with the water-proofing composition. The belt is provided with small diaphragms to prevent the lumps from suddenly falling into the mixture. The continual dipping of the coal into the waterproofing fluid is effected by the aid of small balls placed on both sides of the belt and running in curved grooves in the sides of the receiver. Any excess of moisture adhering to the lumps when these emerge from the fluid drips away through the wire belt into a trough below, from which it flows through a pipe into a receiver provided for this purpose.

The waterproofing composition used by Loiseau consists of resin or some kind of gum dissolved in benzine. In order rapidly to volatilize the benzine, the coal, after passing through the fluid, is discharged into the hopper of a second tunnel, smaller than the drying tunnel, and containing only three endless wire belts arranged one above the other. A strong current of air is driven through this tunnel by a ventilator, causing rapid volatilization of the benzine, while the coal passes from one belt to another. From the last belt it falls through a trough into a coal cart standing

outside. The end of the trough can be raised to permit the filled cart to be removed and an empty cart to be brought under the trough.

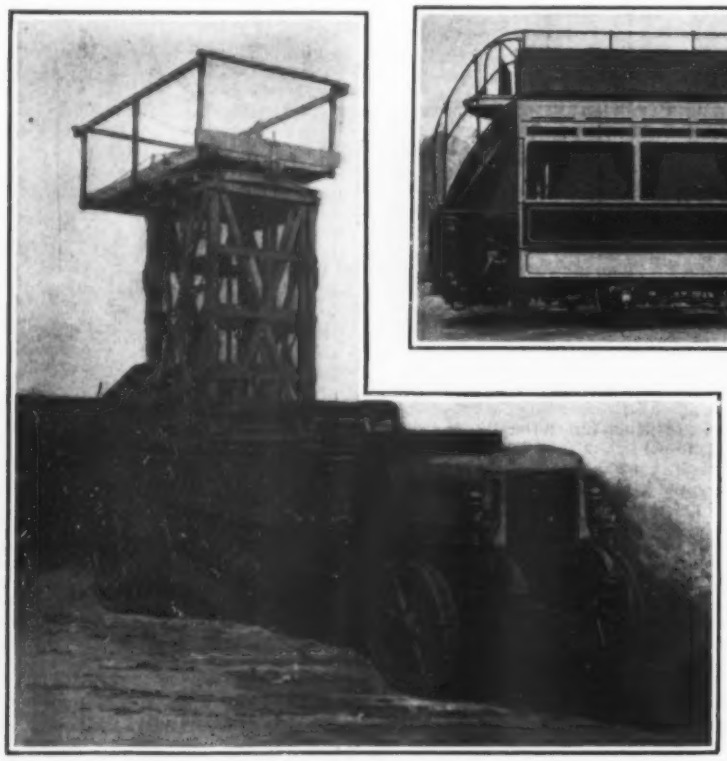
While the product is being conveyed through the tunnel, the hot air is brought into contact with all the coal, and rapidly dries it. The whole process of conversion into artificial fuel is carried on automatically from the moment when the coal dust is dumped into the first hopper; the dust and clay are mixed with lime milk in the proper proportions, the mass thoroughly kneaded and pressed into oval lumps, dried and made waterproof, the benzine volatilized and the finished product put into carts, in each case by purely mechanical means. The coal is in constant motion during the entire treatment.—From the German of Dr. Theodor Koller in Handbuch der rationellen Verwerthung, u. s. w., von Abfallstoffen jeder Art.

SOME RECENT INTERESTING INDUSTRIAL APPLICATIONS OF THE GASOLINE MOTOR.

By the English Correspondent of SCIENTIFIC AMERICAN.

THE development of the internal combustion engine for tractive purposes has rendered it applicable to many types of vehicles for which either steam and electricity are not eminently suited either from point of cost or convenience. The most salient advantage of the gasoline motor for this class of work is the celerity with which it can be called into requisition at a moment's notice, without any preliminary preparations such as raising steam or maintaining the furnace when idle and awaiting utilization, as is the case with the steam vehicle, while it has a greater radius of action and is more mobile than the electrical vehicle when propelled by either battery or trolley power respectively. This factor is amply demonstrated by the fact that the London County Council maintain in constant readiness a motor-propelled breakdown car in connection with the metropolitan electric surface railroads. When a trolley car becomes incapacitated from failure of the mechanism or other causes, the gasoline relief car is able to proceed to the point of the breakdown, and the repairs can either be immediately effected on the spot or the defective car can be towed to the car sheds, thus minimizing the disorganization of the system.

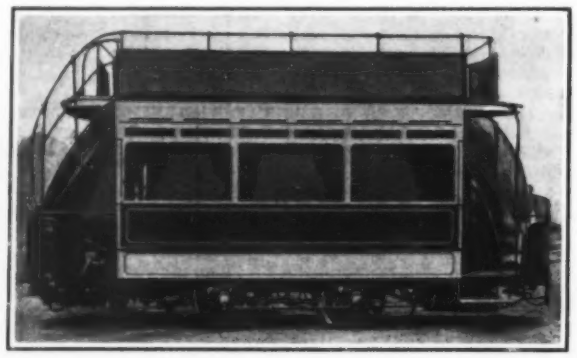
Similarly, other surface railroad companies which employ the overhead trolley system of traction maintain a fleet of gasoline-propelled vehicles for attending and inspecting the trolley wires. In the accompanying engraving a typical inspection and repair car of this type is illustrated. This particular vehicle is one of three that have been supplied to the corporation of Belfast for their street railroad system by the Lancashire Motor Company, of Leyland. The three vehicles are identical, and are each propelled by engines developing 22 horse-power. The motors are of the four-cylinder, vertical, water-cooled type, with a bore of 4½ inches and a stroke of 5⅛ inches, developing the maximum power at 1,000 revolutions per minute, and possessing all the various improvements evolved by these builders. The chassis has a long wheel base, and is of especially stout construction, to carry the heavy dead weight of the tower affording access to the trolley wires.



A 22-HORSE-POWER GASOLINE TOWER WAGON FOR REPAIR AND INSPECTION OF TROLLEY WIRES OF BELFAST.

The tower is constructed of oak throughout of ample strength, and supported by an iron frame. It is telescopic, the elevating motion being effected by means of a screw, giving a maximum height of 20 feet from the road level to the working platform and a minimum elevation of 13 feet 6 inches. The platform at the top of the tower is of the revolving pattern, the motion being controlled from the platform itself, so that the engineers can adapt the platform to that position which is the most convenient for them to accomplish the work in hand. Behind the tower at the rear end of the vehicle are placed ample-sized compartments for the accommodation of tools and any reserve materials likely to be required in the repair of a trolley wire. Seating accommodation is provided for five mechanics in addition to the driver, but in emergency cases more men can be carried.

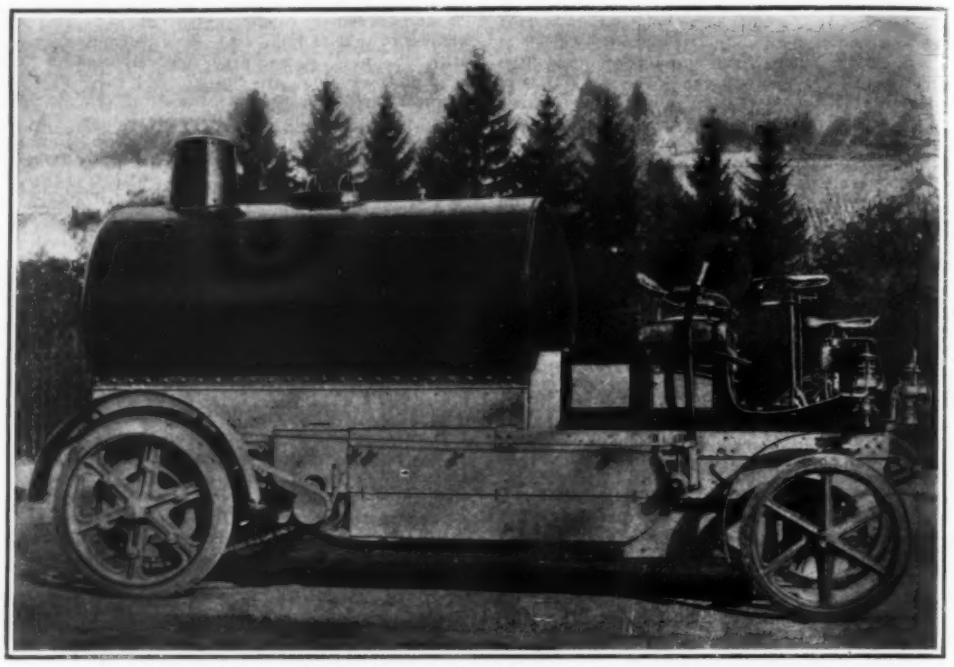
The vehicle is fitted with three speeds forward and one reverse, giving respectively 3.75, 7.5, and 15 miles per hour forward and 3.75 miles reverse. The change-speed gear system adopted is that by which the gear wheels are always in mesh, and a valuable feature of this mechanism is that should the driver, when negotiating a hill, in changing his speed miss the gear, the lowest ratio automatically comes into mesh, thereby preventing any possibility of the car, through the missing of the gear, running backward on a gradient.



A 24-HORSE-POWER CAR FOR SERVICE ON AUSTRALIAN RAILWAYS. CARRYING CAPACITY, 50 PASSENGERS.

These vehicles have proved of great advantage, since with them not only is it possible to reach a defective point in the trolley wires in a short time, but they also enable the inspection to be carried out expeditiously. The whole track is thoroughly examined every night, and the crossovers twice daily as being the most susceptible to the development of a defect.

An interesting garbage-collecting motor-propelled wagon was recently supplied by Messrs. Moss & Woodd, of London, for operation in Cairo. This vehicle possesses several interesting features, having been designed to fulfill specially arduous work in Egypt. The vehicle is of the "Orion" type, which has achieved conspicuous success upon the rugged roads and steep gradients of Switzerland, where it has been submitted to severe transportation tests by the Swiss military and postal authorities. The chassis is exceptionally strong and substantial in construction throughout to withstand the severe stresses imposed by roughly-made roads and steep gradients. The motor is the patented Orion horizontal type, twin cylinder, water-cooled type of engine. Its cylinders are opposed and they develop 20 to 22 horse-power at 600 revolutions per minute. The cylinders are jacketed throughout their entire length, pock-



A GASOLINE MOTOR-DRIVEN SEWAGE-COLLECTING WAGON FOR SERVICE IN EGYPT. CAPACITY, 550 GALLONS.

ets being avoided, so that a free water circulation is insured. The engine is set transversely in the frame, the heavy crankshaft carrying the flywheel, which is of large and heavy dimensions, at one end, while at the other it carries the necessary gear wheels for operating the tappets of the mechanical exhaust and inlet valves, as well as the governor, circulating pump, and magneto ignition. The power is transmitted from the engine through a leather-faced cone clutch and Renold silent chain to the change-speed gear box, which is of the usual sliding type, giving four speeds forward, ranging from a minimum of 3 miles to a maximum of 12 miles per hour, and a reverse. The change-speed mechanism is operated by a small handle and quadrant placed on the vertical steering column just below the handwheel. From the countershaft the transmission is continued to the driving wheels by Renold block roller chains and sprockets. The wheels are of steel and shod with solid rubber tires, those on the rear wheels being of large diameter, so as not to sink easily in the sandy roads. The sewage tank is of 550 gallons capacity, and the vehicle with full load can negotiate a gradient of 1 in 7.

The haulage capacity and economical operation of the Orion motor have been demonstrated upon the Uerlikon-Bauma railroad in Switzerland. This is a typical Swiss mountain railroad, abounding with severe steep and sharp gradients. The Orion motor-propelled railroad car for this service is of the twin-cylinder type developing 32 horse-power, and the car in which it is fitted has accommodation for some 25 passengers. The speed on the level is 24 miles per hour, and the gasoline consumption is 2 gallons per hour, representing a consumption of 0.0625 gallon per horse-power per hour at a cost of 1.125 cents.

For surface railroads in remote districts where the conditions are not such as to insure the profitable operation of the ordinary mechanical traction systems such as steam, electricity, or cable, and animal-drawn haulage is not satisfactory, the motor-propelled vehicle possesses many advantages. In the first place, the initial outlay is considerably reduced, as the necessity of large power installations is dispensed with, while at the same time, owing to each vehicle being self-contained as regards its motive power, it becomes a complete unit, and consequently the whole of the system is not held up until a defect is remedied, as is the case in both the electrical and cable systems.

In view of these circumstances, a large fleet of gasoline-propelled cars has been ordered for service upon an Australian street railroad from the Scottish Motor Engineering Company, of Granton, near Edinburgh. One of these vehicles is shown in the accompanying illustration. The cars are of small passenger-carrying capacity, owing to the gage of the track and the exigencies of the district for which they are intended. The car, however, is of the double-decked class, in this way provision being made for fifty passengers. The vehicle, however, contains many interesting features, especially in connection with the transmission, change-speed gear, and control.

The motor is of the four-cylinder, vertical, water-cooled Granton type, and of extra strength to withstand the strains of continuous work under varying load factors. The engine is mounted on a steel frame beneath the winding staircase, affording access to the roof seating accommodation, at the extreme end and

side of the frame, so that it is completely out of the way and yet readily accessible. It is held firmly in position by the bedplate.

The control of the engine is completely automatic, so that the driver is relieved of the constant attention to the ignition and throttle. The maximum speed of the engine is 700 revolutions per minute, but the speed is adjusted automatically to the requirements of the load. When pulling a light or heavy load on a level road the engine runs at a low number of revolutions per minute, and directly a gradient is encountered it gradually increases in speed up to the maximum number of revolutions.

The transmission is of the Granton type, the power of the engine being transmitted through a friction clutch of large diameter, thence through the Granton compound starting gear, and finally through suitable gearing direct to the axles, no chains being employed. This gearing is fitted into a strong cast-iron frame which is secured to the steel framing and linable to the engine, the steel frame in turn being connected to the ends and sides of the car by bolts. The feature of this drive is its simplicity. It is absolutely impossible to break up the gear boxes, as the change speed gear is always in mesh, and in changing from one speed to another there is no noise or vibration, and lastly no "jump" and forward rush when the clutch is engaged with the engine, as in the ordinary case of driving an automobile by inexperienced men. Consequently there is a considerable economy effected in wear and tear, and a corresponding saving in the maintenance expenses, since the wearing of the gear wheels constitutes a frequent source of renewals in the majority of commercial automobiles, especially if in the hands of an unskilful driver.

The water and gasoline tanks are of sufficient capacity for traveling 100 miles without replenishing. In running these vehicles are very economical, the fuel consumption approximating 0.125 gallon per horse-power per hour, at a cost of 2.5 cents.

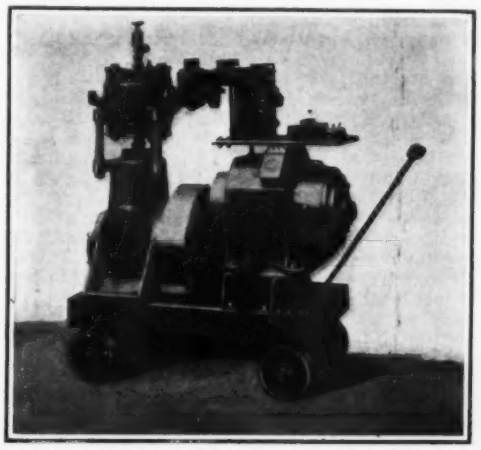
Owing to the automatic governing of the engine, the control of the vehicle is considerably simplified, the drive being controlled by a single handle. The car can be driven from either end, and is so arranged that it can only be driven in one direction; that is, forward from either end. The driving control handle is detachable, similar to those employed in electrically-propelled cars, and on removing this from one end of the car the control is locked at that end, while the placing of the handle in the control mechanism at the opposite end unlocks the gear at that point, enabling the car to go forward.

The driving platform at either end is 5 feet in length, the total length of the car being 23 feet. Each platform is equipped with dash plates and chain and lever brakes, while sanding gear is also provided. The internal seating accommodation is 13 feet in length by 6 feet in width, and 6 feet 8 inches in height from floor to center of roof. The complete weight of the car unladen is approximately 4½ tons, and it is capable of negotiating a gradient of 1 in 15 with the maximum passenger load.

The employment of the internal combustion motor for portable air-compressing plants has been considerably developed for a variety of purposes, such as for the cleaning of furniture and masonry by the vacuum system, and the supply of power for operating small pneumatic tools. An interesting combined plant of this type designed by the Tilghman Patent Sand Blast Company, of Manchester, has been recently completed, in which the gasoline motor is utilized for the dual purposes of driving the containing vehicle and the air compressor for cleansing purposes. The motor is a 20-brake-horse-power vertical type driving the lorry through the usual change-speed gearings at speeds ranging from 3 to 6 miles per hour, and a minimum speed of 3 miles per hour on a gradient of 1 in 9. It develops sufficient power to compress 110 cubic feet of free air per minute to a pressure of four atmospheres. The air compressor is of the vertical double-cylinder single-acting type running at 300 revolutions per minute, driven direct from the motor through a pinion and spur wheel. The air receiver is 4 feet in length by 1 foot 6 inches in diameter, and is placed beneath the driver's seat. The air pipe from the compressor to the receiver is carried round the famework of the vehicle before it enters the receiver, so that any water that may be entrained with the air after compression may be separated. The water-cooling tank is adapted so that the circulation for cooling purposes can be connected to both engine and compressor, or to the motor cylinders only if desired. A smaller plant on the same lines has also been in operation for some time. In this installation the plant is carried upon a small trolley, and the compressors have a capacity of 48 cubic feet of free air per minute. The gasoline motor is of 7½ horse-power, and the compressor is capable of pressures up to 100 pounds per square inch. In operation these plants have proved highly efficient and economical. They are more convenient to handle than other power systems, less expensive to maintain, and what is of far greater importance, less cumbrous and weighty, thereby facilitating portability.

The London County Council have acquired a combined and self-contained plant, the power for which for all purposes is supplied by a gasoline motor, for carrying out the most frequent causes of trouble upon the tracks of their electric street surface railroads. This plant accomplishes the respective functions of grinding down inequalities in the track rails, the renovation of "lippy" joints, the milling of the conduit slot to the requisite gage, which has become somewhat closed owing to the constant contraction and expansion of the road surface, and the drilling of holes in the track rails upon the spot. The general design of this interesting plant may be gathered from the accompanying illustration. The frame is of steel well braced together and mounted upon two pairs of wheels. The gasoline motor develops 12 B. H. P. at a normal speed of 1,000 revolutions per minute. The power is transmitted through clutches and gearing, giving two speeds of 4 and 6 miles per hour in either direction.

The grinding wheels are 10 inches in diameter and



PORTABLE MOTOR-DRIVEN AIR-COMPRESSOR.

Capacity, 48 cubic feet per minute. Motor, 7½ horse-power. Maximum pressure, 100 pounds per square inch.

are of three gages—2 inches wide for grinding the face of the rail, 1 inch wide for grinding the tip, and ¾ inch for the groove or tread—and completely inclosed to prevent dust and water flying while the grinding operations are in progress. The wheels are mounted upon a spindle carried by adjustable bearings, and connected by telescopic shafts and universal joints to the gear casing, and permit of vertical movement of the slide and transverse movement of the bearing. The grinding wheels can take a 2-foot cut at one operation.

An automatic track drill is fitted with two twist drills, and is operated by flexible shafting through an instantaneous clutch which enables the operator to stop the drill without stopping the motion of the flexible shaft. The milling cutter is mounted upon a compound slide for adjustment, and the power is transmitted through similar flexible shafting. By means of this plant repairs to the track can be carried out expeditiously, and the plant being self-contained it is able to travel from one point under its own power. There is a similar plant in operation upon the street railroads of Nottingham, the engineer of which designed this installation, but in this case the power is derived from the trolley wires. This principle however possesses many disadvantages, since the machine can only be operated when current is available, and consequently any failure in this supply renders the plant useless. Furthermore, it has been demonstrated that by utilizing a gasoline motor for both driving the vehicle and the various tools, an appreciable economy is effected, and the maintenance expenditure of the track considerably reduced.

COMBINED GASOLINE MOTOR-DRIVEN LORRY AND AIR-COMPRESSING PLANT FOR CLEANING PURPOSES.

The specific gravity of non-conducting materials is in many cases of vital importance. For marine work, especially, take, for instance, a steamer of the size of the "Teutonic," of the White Star Line, the difference in weight of the covering applied, which was of low specific gravity, effected a saving of over 100 tons in weight. If the work had been done with high specific gravity material, says Mr. Ashby W. Warner in a paper on "Non-conducting Work," read before the Cleveland Institute of Engineers, this steamer would have carried over 100 tons dead weight more than was necessary.

UNSOLVED PROBLEMS IN METALLURGY.*

By R. A. HADFIELD.

HEAT Treatment.—As an illustration of the complex nature of the problems with which the metallurgist has to deal, I will specially refer to the effect of heat treatment upon the metal iron and its alloys. One example is found in the curious magnetic properties of high nickel-iron alloys and iron-manganese alloys. While the alloys appear practically non-magnetic at atmospheric temperatures, upon cooling down in liquid air they become considerably magnetic, and remain in this state until again raised to about 500 deg. C., when they become non-magnetic. This cycle can be carried out as often as desired with the same result.

These structural changes must be very great, for the special steel containing 20 per cent of nickel, which is almost non-magnetic or only feebly so, has a tenacity of 44 tons per square inch, and elongation of 55 per cent, a reduction of area of 63 per cent, and can be readily machined at ordinary temperatures. Upon being immersed in liquid air, however, it becomes strongly magnetic, its tenacity increases to the extraordinary figure of 157 tons, while its ductility still remains fairly high—namely 15½ per cent—and it can now only be machined with difficulty. This steel after returning to atmospheric temperature retains a tenacity of no less than 115 tons per square inch, or more than 2½ times that of its original condition, and has an elongation of 4½ per cent.

The alloy of iron and manganese with which I have worked so many years is not, singular to say, affected by any change in temperature, whether the highest or that of liquid air; it always remains non-magnetic except when annealed for a long period.

Electro-Thermic Smelting of Iron and Steel.—There are many unsolved problems to be worked out in connection with the production of steel. The Bessemer and Siemens-Martin processes have been carried to a great refinement, and the material produced by them, as regards quality, holds a high place in engineering construction, while the rapidity of production and low cost they have made possible are economic advantages of a high order. Beyond improvements in detail, none the less important because they are small, these processes remain in principle much as they were originally. It will probably be a long time before they are supplanted.

There are those who look forward to an electrical method of producing iron and steel. If any practical system of this nature for converting iron ore into pig iron or steel could be introduced, using the stored-up powers of Nature instead of burning carbonaceous fuel, the revolution in practice would be great. Probably over 100 million tons of coal, equal to about one-seventh of the world's total output, are used annually in the smelting of iron, to say nothing of the further large quantities employed in the subsequent working of iron and steel into more finished form. Where water power and suitable iron ore can be found together, then, no doubt, satisfactory electrical smelting practice will be developed, but this can only come slowly.

Pioneer work is being done in Sweden, France, and Canada in electrical smelting for the production of steel, but unless water-power can be obtained at economical rates it would seem that the application of this system must remain very limited; that other sources of power should be used at present appears out

* Extracts from the fourteenth "James Forrest" Lecture, delivered at the Institution of Civil Engineers.

of the question from an economical point of view. Moreover, the electric furnace does not purify steel more than other furnaces not specially adapted to that purpose. Bad steel can be produced by it just as easily as by ordinary processes. Some of us know how often the old type of crucible steel melting, so largely practised in Sheffield, has been threatened with extermination, but more material is now produced in this way than ever before. The electrical system has in this older method, notwithstanding its extraordinary wastefulness, a competitor that will not soon be annihilated. There is no magic in the electrical method as it would almost seem some would have us believe. Steel made by it shows similar analysis, and has the same physical qualities as that produced in other ways.

Electric Furnaces.—An important question in connection with electric furnaces is, whether they can insure uniformity of temperature. It is well known that they are apt to produce steel which is much colder at the top of the molten bath than underneath; this is, of course, objectionable. Of the many failures with electric furnaces we hear little; it would be interesting to know more about them. I say this in no disparagement of a "young" process, but to prevent the uninitiated being dazzled by the mere term "electric."

It is stated that the efficiency of the electric furnace is already comparatively high, say, 50 per cent, but under present conditions it would still be more expensive to develop heat at any temperature within the range of a coal-fired furnace by electricity than by coal; that is, if electricity has to be generated by steam power, even with plant of the highest efficiency.

The electric furnace has a range of temperature of about twice that of the ordinary steel furnace, so that it will extend up to about 3,000 deg. C. Reactions which take place within certain limits of temperature as now practised may be reversed at the higher range made available by the electric furnace.

While speaking of high temperatures it may be pointed out that no one knows the behavior of the elements present in the sun, the temperature of which is estimated to be between 7,000 deg. C. and 8,000 deg. C., neither can we foresee what will be the behavior of metals at temperatures above the limit of our present ordinary furnaces, that is, above about 1,500 deg. C.

Alloys and Their Special Properties.—In the brittle iron-manganese alloy containing 4½ per cent manganese, the properties of iron seem quite reversed. Although the carbon present is comparatively low, yet this alloy is more brittle than cast iron. With an increase of manganese to about 12 per cent the properties of this alloy again entirely change, and it becomes of more than ordinary interest. When forged and treated, this steel has a tenacity of about 60 tons per square inch, with a ductility of 40 to 50 per cent, or considerably more than that of pure iron. Yet the determining factor, manganese, is in itself an exceedingly brittle metal. It also becomes practically non-magnetic, and, unlike certain nickel-iron alloys which also appear to be non-magnetic, but are reversible, it cannot be rendered magnetic even by quenching in liquid air, nor does ordinary heating render it magnetic. When it is considered that the same metal, manganese, combined with copper and aluminium in the material known as the "Heusler" alloy, gives a magnetic product, although no iron is present, it will be recognized what a wonderfully wide field for research is offered by alloys of various kinds. The results to be expected are so curious that it is not possible to generalize from one to another; each alloy must be worked out.

While speaking of magnetic properties, one of our profound thinkers in electrical problems, Dr. J. A. Fleming, F.R.S., in a joint paper by him and myself to the Royal Society in June last, considers it is very probable that ferro-magnetism, *per se*, is not a property of the chemical atom, but of a certain kind of molecular grouping. The importance of this cannot easily be overstated. It shows that, in spite of the fact that ferro-magnetism has been hitherto regarded as the peculiar characteristic of certain metallic elements—iron, nickel, and cobalt—this may depend eventually upon molecular grouping, composed of a comparatively large number of molecules; hence it may be possible to construct alloys which are as magnetic as, or even more magnetic than iron itself. Attention may be drawn to the brilliant researches on alloys of iron with other elements by Mr. L. Guillet, of Paris, who has this year been awarded the Carnegie Gold Medal.

Another illustration of the peculiar nature of these iron alloys is that of "Resista" steel, already described before our Institution. This material contains 80 per cent C, 6 per cent Mn, about 15 per cent Ni, and the rest iron. In the cast form it can be bent double when cold, as illustrated by the 2½-inch bar shown. When forged, its tenacity is 58 tons per square inch, with the extraordinary elongation of 60 to 70 per cent. This alloy is only feebly magnetic until cooled in liquid air, when its magnetic properties are considerably increased, but it is not embrittled by this treatment. Now a singular fact regarding this alloy is that if either the manganese or the nickel is omitted, an extremely brittle product is the result; but combined together they produce the most ductile iron alloy known. The curious electrical properties of this and many other iron alloys have been carefully studied by Prof. W. F. Barrett, F.R.S. They were illustrated by a number of experiments and researches in which he and I collaborated.

A number of alloys, also metals, have peculiar properties, including inert, pyrophoric alloy, magnetic copper alloy containing no iron, tantalum, manganese chromium, 75 per cent silicon alloy, hematite cast iron containing only 33 per cent silicon, yet at the same time no less than 2.03 per cent graphite. The pyrophoric alloy contains 30 per cent iron, also cerium and other rare metals. The pyrotechnic display on scratching with a file makes it of spectacular interest. "Inert" is a non-magnetic cast iron, containing about 13 per cent manganese, yet at the same time it is machinable.

From this short summary it will be seen how extraordinary are the properties of different alloys, and that a knowledge of each of the metals of which they are composed may not necessarily be any guide as to the properties when alloyed together. The field is immense, and the future progress of the metallurgical world largely depends upon research which will enable us to correctly understand and interpret the laws at work in producing these curious results.

In a useful paper on "Ferro Alloys" recently read before the Institution of Mining and Metallurgy, Mr. O. J. Steinhardt, Ph.D., F.C.S., points out the importance of this subject. With the many metals and alloys now at our disposal the number of useful alloy steels which may be produced has been greatly extended. The study of these affords a field of such magnitude that it requires the ceaseless investigation of master minds to select those combinations which give the desired results with the least expenditure.

Pyrometry.—Such immense strides have been made in this branch of science during the last decade that when we look back the advance appears marvelous considering the short time that has been occupied by the work.

It is but a few years ago that any correct determination of high temperatures became possible; chaos is the only word suitable to the conditions previously existing. Misleading data only increased the confusion. Now, by means of the modern pyrometer, temperatures up to 1,100 deg. C. or 1,200 deg. C. can be determined within a few degrees: in fact, Callendar claims that by his research instrument it is possible to indicate within one-tenth of 1 deg. C. Modern advance in metallurgy largely depends upon working within extremely narrow ranges of temperature in heat treatment, and for this reason our debt is great to the scientific men in this and other countries who have helped to solve this important problem. Four names are specially prominent—Siemens, who originated the electric resistance pyrometer; H. le Chatelier, a Frenchman to whom we are all indebted, and Callendar and Roberts Austen of this country.

THE METALS IN HUMAN PROGRESS.*

By NELSON P. HULST.

EVEN a cursory study of any of the manifold activities of the human race which have had a share in carrying it forward and upward from an almost purely animal condition, is a source of deep gratification. Yet it is grievous to know that even in present times there are to be found in remote parts of the earth some tribes of the human family which have never known the comforts, the joys attending an advance out of savagery. They and their ancestors from the remotest time have possessed only the heritage of the earliest savages, adding nothing thereto by their own invention.

The influence which the discovery and the use of metals, just a few of them, have had in uplifting man from his early low estate, is measured by the betterment of his physical condition and surroundings, the expansion of his mental powers, the evolution of his moral and esthetic sense. These constitute the long stride from savagery to the highest degree of civilization.

Just a glimpse at the history of some of the long-known metals, in so far as they have affected the destinies of our race, reveals a drama of all-absorbing interest. Primitive man came on the stage of action a savage, having no knowledge of metals, possessed of neither weapons nor tools, and yet compelled to struggle at great odds against the fiercer animals which disputed his presence at every point. Lucretius, writing of man's early estate and his dearth of weapons, surmises that then his only means of offense and defense were "his teeth, and nails, and stones and fragments from the branching wood." This we are fain to believe must have been his first condition. Authentic written history has handed down to our age a more or less clear picture of the period of man's life on the earth, from and after the time when the art of writing was invented. It depicts the surroundings of man as far back as six thousand years and more ago. A portion of the human race had then acquired a considerable knowledge and use of metals, and had risen from savagery to a considerable, though rude, civilization. But there are other records of our race, not set in written form, which antedate the written records by vast periods of time and yet are quite as reliable as the authentic written records.

These records, which have to do with the life of man during those unnoted centuries that reach back into the mist and gloom of a most remote past, are the study of the geologist and the archeologist. From all the data secured by these investigators respecting the very early period of man's existence, this period, which reaches back far, very far, beyond the dawn of written history, far into the darkness of man's intellectual night, it is clear that he began his existence not "a little lower than the angels," but on a plane scarcely higher than that of the brute creation. Mason in the "History of Invention" says the first of our species were poorly provided with apparatus for contending with their fellow creatures, or even defending themselves therefrom. The lower forms of terrestrial and marine life were accessible to them, and the young of many higher mammals, but the conflict must have been slowly and feebly waged at first. The account of the ways along which the animal world had gradually succumbed to our species, would involve the whole history of civilization. All this conflict was in front of the first man. No other animal started ever on such a mission. His problem was to invent missiles that would fly faster than the objects of their pursuit.

Such records as the archeologists present, which show in a measure the condition of primitive man, well establish the fact that human beings in considerable numbers dwelt in natural caves in Southern France. The bones of animals were mingled in these caves with the bones of men and women. There were the bones of the hairy elephant or mammoth, of the reindeer, and of musk sheep, all of which are truly Arctic creatures. The hairy elephant was an extinct animal at the beginning of written history. Hence it is evident that at the time when men inhabited these caves in Southern France the climate of the region was wholly Arctic, as frigid as that of the most northerly portions of Siberia. Among these relics of human and animal life no traces of agriculture were found, in the way of tools for tillage. Lance and arrow heads and stone hammers, all unpolished, together with bone and ivory needles and awls, were found in abundance, evidently of the same age as the bones they were mingled with.

As much of a savage as primitive man then was, he evidently possessed a sense of the artistic, for sculptured reindeer antlers, and a tusk of the hairy elephant, were found in a cave among the bones mentioned, and in such relation to them that they have been acknowledged to be of the same age.

But among all the relics of mankind, which are now numerous and which have been found similarly in caves in other lands widely distant from Southern France, no trace of any of the metals has been discovered. During this period of man's existence, evidently he had no knowledge of metals. We might believe that the glittering nuggets and grains of gold in many a stream bed would have aroused the curiosity of the primitive man. Apparently, however, such a substance did not interest him. This period, when the most advanced of the tribes and peoples of the human family contrived and fashioned their weapons and tools from stone or from the more fragile materials, shell and bone—this period has been given the name of the Stone Age. As man progressed in experience and came in the lapse of time to discover some of the metals, more especially copper and tin, he found that the melting together of these two metals produced a new metal, an alloy superior in all respects to its constituent metals. This alloy we call bronze, and the interval of time covering the general use of it is called the Bronze Age.

There are no definite boundaries to the Stone Age. It reaches back very far toward the date of man's creation, over an unfathomable abyss of time. Its later boundary is coeval with the dawn of the Bronze Age. Yet according as some tribes of men continue to-day in the savage state, and have still in use only stone weapons, for them the Stone Age still exists. Nor can it be stated what interval of time the Bronze Age covers. Its hither boundary only can be given, which is about 500 B. C., when iron came into quite general use. The other boundary of the Bronze Age reaches back into a past antedating all written history.

Man's earliest knowledge of bronze implies a still earlier knowledge of copper, since it is one of the constituents of bronze. Copper occurs now as a native metal in many of the regions of the earth which were the homes of mankind before written history began. In ancient times, before the use of copper, this native metal must have been frequently found in masses, large and small. The beautiful red color of this metal, its resplendent luster when polished, the brilliant blue and green hues of its oxides, which are often seen on masses of the native metal, its great specific gravity—these were qualities which eventually must have attracted the notice of man before the dawn of the Bronze Age. The North American Indians within a century or so hammered out arrow and spear heads from the small masses of native copper, such as are found to-day scattered very sparingly in the drift material which in some remote period has been eroded from the copper-bearing rocks of Lake Superior. The semi-barbarous Mexicans, at the time of the discovery of the western hemisphere, were considerable users of metallic copper. There was such pressing demand for copper among prehistoric tribes of North America, that these rude people, in their diligent quest of the metal, traced out the source of the native copper masses occurring in the drift, which had proven an insufficient supply. Even to-day the traces of their crude work for securing considerable masses of copper are seen at various points in the Michigan copper district. Their only mining tools were heavy stone hammers. A half century ago these stone hammers were found in abundance in shallow excavations, along with the masses of copper, which were partly uncovered or detached from the amygdaloid rock in which they had been first found. Just as the prehistoric peoples of North America made their weapons and tools from the small masses of copper, which they hammered into acceptable shape, so we can believe that prior to the beginning of the Bronze Age primitive man fashioned the smaller copper masses into his needed implements.

The larger masses he was unable to divide and sub-

*Specially prepared for the SCIENTIFIC AMERICAN SUPPLEMENT.

divide with stone hammers, his only mechanical means. This embarrassment of riches must have plunged the ancient arrow-makers into a whirl of perplexing thought. In some eventful moment it must have dawned on some one of them that fire might splinter into fragments these troublesome copper masses, as it did their familiar hearthstones. What a startling surprise the result of applying fire to copper masses must have been! There was no splintering accomplished by fire, nor did fire change or remove the valuable qualities of the metal, as he had seen happen in some degree to his hearthstones, or wholly so to the wood he burned. He discovered that, on the application of a fierce fire to copper, it softened, melted, flowed away as a thick liquid, and that in its cooling it took on the conformation of the surface over which it had flowed. He further discovered that by melting copper he was enabled to divide and subdivide the larger masses which hitherto had been altogether useless to him. These were new and astonishing facts thrust on the man of the Stone Age by his first success in melting copper. Then and there a new world of possibilities was opened to him, by the discovery of a new use for fire. From that eventful occasion there was a quickening, a development of his mental faculties, such as he had never known previously. In the past his intellectual faculties had been but feebly active. Only cold or hunger or passions or fear impelled him. With this discovery his mental self was started from a state of rest to that of motion. One writer has said that "among the many stages in the development of primeval man, none can have been of greater moment to him in his struggle for existence than the discovery of metals and the means of working them." While this is very true, as relating to his struggle for existence, and to a satisfying of his animal needs, it was of vastly profounder moment to primeval man that this discovery of the means of working metal by fire awoke his dormant mental faculties and begot in him a hunger of the mind which thenceforth has never known satiety. Butler in his "History of Mankind" says in this connection, "The gifts of nature most valuable for man are those through which his latent sources of force are thrown open in permanent action."

This discovery of working copper by means of fire was the very dawn of metallurgy. What were the immediately subsequent steps followed by man in the development of the metallurgy of metallic copper and copper ores in prehistoric times, will never be ascertained. We can be sure, however, that there must have been a constantly growing activity and skill in its production, and an increasing ability to fabricate it into the numerous implements his growing needs demanded. Yet copper lacked a most essential quality—that of hardness, sufficient to give a durable cutting edge, or a resistless point to his weapons and tools. We can correctly surmise that primitive man, when once his mental powers were aroused by his success in melting copper, would be promptly stimulated to try by fire the ores of copper, of silver, of tin, as well as metallic gold and meteoric iron, and ores of iron, if not also other metal-bearing minerals.

For many ages prior to written history he was possessed of gold and silver, tin and iron. In an early chapter in the book of Genesis it is mentioned that Tubal Cain was a forger of every cutting instrument of brass or bronze and iron. Although copper in early prehistoric time was the most plentiful metal in use, in consequence of being more readily obtained by smelting than any of the other metals known to primitive man, its usefulness was seriously limited, because no method as yet had been discovered by which it could be made sufficiently hard. How laboriously the pioneer metallurgists must have sought for a means or method of treating copper to accomplish this result! Perchance it was this one lacking quality of copper which stimulated the search for other metals, which by melting with copper would give it this most longed-for quality. In modern times we have had a familiar and somewhat analogous example of wearisome search for a means to accomplish a longed-for result, and its final abundant success. The task in this instance was to discover some method of manipulation of the crude rubber of commerce, or to find the proper substance to mix with it, so that its valuable qualities would be preserved as well as increased. While a far greater knowledge of the properties of many substances was possessed, and the influence they would have in combination with other substances was known, yet withal years of tireless, unremitting effort were expended on the discovery of some material or some method whereby this crude rubber could be given the longed-for qualities. At last, by an accident it is asserted, Goodyear, the patient investigator, succeeded by a treatment of it with sulphur in producing rubber with the qualities which make it of such inestimable value to mankind. So it was, probably, with primitive man, in his search for a method of manipulation or of a metal to mix with copper which would give it hardness. We do not know where or when in the gray dawn of antiquity he accomplished his quest, nor do we know how it came about, for it was an accomplished fact, an old, old discovery of many ages, before Genesis was written or before the Vedic poets began their sacred songs. We only know by the innumerable bronze relics of those bygone, lost ages in man's history, that these early, primitive metallurgists conquered their problem most grandly. By their discovery they produced for humanity a new compound metal of really priceless value, by melting with copper a small percentage of tin. It seems now a small thing, yet among all the brilliant discoveries or inventions, and they are many, which have given brightness to any age, which have helped to upraise man to a higher estate, quickening his ambition, arousing his mental activities, none has been of greater assistance in his advancement, none has been more potent in improving his physical conditions and surroundings, than this discovery or invention in early prehistoric times of producing bronze.

It is always at the first step, always at the birth of an idea, that halting and wavering occur. When the first step is firmly taken, when an idea, a purpose, is crystallized into definite shape, then come many followers, to assist with their skill and their efforts, and the march of progress begins. The first success in producing the bronze of the ancients was no doubt accomplished only after many years of disappointing failure. But when the goal of effort was reached by some patient metallurgist of old, the full tide of man's thought was turned upon the production of bronze. In comparing any of the later great inventions with the invention of bronze, we should bear in mind that up to the time when bronze was invented and applied to man's uses, he was, even where most advanced for his time, possessed of the most meager equipment of satisfactory weapons and tools with which to battle for existence.

The later great inventions were accomplished when the human race was more richly endowed mentally, when, in comparison with men living at the beginning of the bronze age, it was abundantly rich in material surroundings, when it was possessed of a much greater knowledge of things, a keener sense of its wants, which is the stimulus of invention, and when it was skilled in the use of some of the physical forces. With the invention of bronze it may be said that industrial art, all art, all efforts of man toward higher, nobler things, had their first great impulse.

The earliest use of gold must have been almost coeval with copper. More than forty centuries before the beginning of the Christian era it was wrought into jewelry with a skill and artistic taste surpassing that of the present day. Gold lacked hardness, which made it wholly unsuitable for tools or weapons. Its comparative scarcity and cost of production would have barred it generally from such uses. After the invention of bronze, it appears that those races of men possessing the knowledge for its production were stirred into a restless activity. This powerful unrest engendered among the ancient Aryans resulted finally in the dissolution of their nation, the most cultured of early prehistoric times. They are believed to have had their primal home in Central Asia, somewhere east of the Caspian Sea, and north of the Hindu Kush Mountains. The Vedic poems, relics of the most ancient literature, tell us of the metals used by the ancient Aryans—iron, copper or bronze, and gold. They describe also the grandeur of those earlier prehistoric times, and mention as of that period the melting of metals, the building of chariots, and the construction of golden and iron mail and golden ornaments. This prehistoric, cultured nation, from some impelling cause, suffered the withdrawal successively of large numbers of its population, until finally all had migrated and the nation became extinct. Although dying thus by the emigration of its people to other lands, the culture of the ancient Aryan nation which these wanderers took with them survived in their new homes. As the scattered branches of Aryan stock in Europe and about the Mediterranean multiplied and became powerful, growing into nations, their civilization also advanced to a glory and splendor which make the charm of history. We do not presume to maintain that these great westward migrations had their sole impulse in the urgent necessity of a supply of metals, but we do think it quite probable that an insufficient supply of them was an important contributing cause of these offshootings from the parent stock. It is prominent in history that wherever in the known world metalliferous ores or metal-bearing rocks existed, such as were needed by these Aryan emigrants, thither their metal hunger caused them to press.

(To be continued.)

ANNEALING METALS.

By W. J. MAY.

FOR many purposes metals have to be annealed, and this has to be done at suitable temperatures if the results are to be of the best. Mere temperature alone is not sufficient, however, as a time element is involved, this varying with the bulk of the pieces of metal dwelt with. Take, for instance, a steel bloom for tube rolling. If made only of the heat necessary for rolling, it will take the maximum power to produce the minimum reduction in size, but if it is soaked for an hour or so in proportion to the thickness of the metal, it draws out with the greatest freedom. Of course the duration of the heat causes changes in the actual structure of the metal, although with proper working very little change takes place in its content, while with close annealing neither change in content nor oxidization to any extent should take place.

Some things, such as chains and other pieces of wrought-iron and steel subjected to stress, need more or less frequent annealing to keep them in a safe con-

RARE ELEMENTS.

SYMBOLS, SPECIFIC GRAVITY, ATOMIC WEIGHT, DISCOVERER, ISOLATOR, PRINCIPAL SOURCE, MELTING POINT, PROPERTIES, ETC.—COMPILED BY E. L. N. ARMBRECHT.

Element.	Symbol.	Atomic Weight.	Discoverer.	Isolator of Metal or Non-Metallic Element.	Specific Gravity.	Principal Source.	Melting Point.	Properties.	Salts.
Barium	Ba.	137.2	Scheele....1774	Davy....1808	4.0	Heavy Spar		Yellow color, readily fusible, oxidizes in air. Decomposes water.	
Beryllium or Glycinum	Be.	9.1	Vauquelin....1798	Wöhler....1828	2.1	Beryl		Zinc-white, ductile and malleable. Not easily oxidized. Soluble in acids.	Oxide.
Boron	B.	11.0		Gay-Lussac....1808		Borax		Very hard, non-metallic element. Two allotropic modifications.	
Calcium	Ca.	40.0		Davy....1808	1.6	Chalk		Silvery white, soft and malleable. Rapidly oxidized in moist air.	
Caesium	Cs.	132.9	Bunsen....1860	Bunsen....1860		Mineral Waters	27° C.	Very soft, resembling Potassium. Rapidly oxidized in moist air.	Hydroxide.
Cerium	Ce.	140.2	Berzelius....1803	Berzelius....1803	5.5	Cerite		Soft and malleable. Slowly oxidized in moist air. Soluble in acids.	Oxide.
Chromium	Cr.	52.0	Vauquelin....1797	Vauquelin....1797	5.9–6.8	hrome Ironstone	Very High	Very hard. Slowly oxidized in air on heating.	
Cobalt	Co.	58.7		Brand....1733	8.957	Smaltine		Very hard. Malleable and ductile. Not oxidized in air. Magnetic.	
Didymium	Di.	142.0	Mosander....1841	Mosander....1841		Yttrocerite		Easily oxidized even in dry air. Decomposes water.	Oxide.
Erbium	Er.	166.0	Mosander....1843			Gadolinite			Oxide.
Gadolinum			Marignac....1880			Samarskite			Oxalate.
Germanium	Ge.	72.3	Winkler....1886	Winkler....1886	5.469	Argyrodite	900° C.	Grayish white metal. Unaltered in dry or moist air.	
Gallium	Ga.	69.9	Boisbaudran...1875	Boisbaudran...1875	5.95	Zinc Blende	30° C.	Soft malleable. Not oxidized in air.	
Indium	In.	113.4	Richter....1863	Richter....1863	7.4	Zinc Blende	176° C.	Silver white, soft and ductile. Does not tarnish in air.	
Iridium	Ir.	193.2	Tennant....1804	(Occurs native)	22.4	Iridosmine	1950° C.	More infusible and more brittle than Platinum.	
Lanthanum	La.	138.2	Mosander....1839	Mosander....1839		Cerite		Resembles Calcium, more rapidly oxidized than that metal.	Oxide.
Lithium	Li.	7.0	Arfredson....1817	Arfredson....1817	0.53	Lepidolith	180° C.	Soft and weldable. Tarnishes in air. Lightest solid known.	Fluorsilicate.
Manganese	Mn.	54.8	Gahn....1774	Gahn....1774	8.0	Manganite		Grayish white metal. Tarnishes in air. Very brittle.	Fluoride.
Molybdenum	Mo.	96.0	Scheele....1778	Scheele....1778	8.6	Molybdenite		Very hard. Silver white metal. Does not tarnish in air.	
Niobium	Nb.	94.0	Hatchett....1802			Columbite		Only known as a brown powder.	
Osmium	Os.	192.0	Tennant....1803	(Occurs native)	21.4			Heaviest and most infusible of metals. Oxidizes readily in air. *See Note.*	
Palladium	Pd.	106.7	Wollaston....1803	(Occurs native)	11.4			White lustrous metal. Malleable and ductile. Does not tarnish.	
Potassium	K.	39.1	Duhamel....1736	Davy....1807	0.865	Carnalite	62° C.	White metal. Tarnishes in air. Decomposes water.	
Rhodium	Rh.	103.1	Wollaston....1803	(Occurs native)	12.2			Harder than Platinum, less ductile, more infusible.	
Rubidium	Rb.	85.4	Bunsen....1860	Bunsen....1860	1.52	Lepidolite	38.5	Very soft. Rapidly oxidizes in air. Decomposes water.	Oxide.
Ruthenium	Ru.	104.0	Claus....1844	(Occurs native)	11.4			Grayish white metal. Very infusible.	
Selenium	Se.	79.0	Berzelius....1817	Berzelius....1817	4.3–4.8	As Selenites	Xtal 220° C	Various allotropic modifications resembling Sulphur.	
Silicium	Si.	28.0	Berzelius....1810	Berzelius....1823	xtals, 2.47	Silica		Non-metallic. Exists in different allotropic modifications.	
Sodium	Na.	23.0		Davy....1807	0.972		97.6	Rapidly oxidizes in air. Decomposes water.	
Strontium	Sr.	87.5	Hope....1793	Davy....1808	2.5	Strontianite		Rapidly oxidizes in air. Decomposes water. Yellow metal.	
Tantalum	Ta.	182.8	Hatchett....1802		10.8	Tantalite		Only known as a black powder. *See Note.*	
Tellurium	Te.	125.0	Klaproth....1798	(Occurs native)	6.1		452° C.	Non-metallic element, but having most of the properties of a metal.	
Thallium	Tl.	203.64	Crookes....1861	Crookes.	11.8	Pyrites	294° C.	Metallic luster. Soft. Oxidizes rapidly in air.	
Thorium	Th.	232.0	Berzelius....1828	Berzelius....1828	11.1	Thorite		Heavy crystalline ivory powder. Burns when heated.	
Titanium	Ti.	48.1	Gregor....1791	Gregor.		Rutile		Only known as dark gray powder. Difficult to fuse.	
Uranium	Ur.	239.0	Klaproth....1789	Klaproth	18.7	Pitchblende		White, very hard metal. Oxidizes on exposure to the air.	
Vanadium	V.	51.0	Cesström....1830	Cesström	5.5	Vanadinite		Silvery white metal. Unaltered on exposure to air. Difficult to fuse	
Wolframium	W.	184.0	d'Elhujar....1781		18.0	Scheelite		Only known as steel-gray crystalline powder. Difficult to fuse.	
Yttrium	Y.	89.0	Gadolin....1794			Yttrocerite		Only known in form of lustrous powder	Oxide.
Zirconium	Zr.	90.7	Klaproth....1789		4.15	Zircon		Resembles antimony. Does not tarnish in air.	
									Samarium Ox
									Ytterbium Ox

NOTE.—Quite recently osmium and tantalum (the two most infusible of the metals) have been commercially utilized in the manufacture of filaments for electric incandescent lamps, taking the place of the usual carbon filaments.

dition, and preferably in such cases the annealing heat should be maintained for a fair length of time; some hours, in fact. Generally speaking, also, close annealing should be insisted on, as this gives the best eventual results, although it does not perhaps show up defects so readily as open annealing would do. At the same time, the freedom from oxidization is of considerable moment in close work, and if rusted metal is placed in furnaces where there is a fair amount of charcoal the oxygen will be taken up without further penetrating the metal. This, however, is a matter of practice which need not be entered into here, but still it is worth noting.

To do good work in annealing it is necessary to have good furnaces, and necessarily these must be built to meet the class of work in hand. Down-draft furnaces will usually be found best, especially in open annealing, and care must be taken that the heat is retained in the furnace as long as possible. This means a careful arrangement of both the inlet from the fire and outlet from the furnace, and in addition it makes an efficient damper to each furnace absolutely necessary. With open annealing no air should pass into the annealing chamber, and the fireplace must be so constructed as to enable the firebars to be covered with fuel the whole of the time the furnace is being worked. As a general rule each furnace has to be separately designed and built so far as open annealing is concerned, although the same general principles are maintained.

With close annealing there is a closed annealing chamber, which has to be heated to the required temperature, and there is a large scope for ingenuity on the part of the builder to secure efficient heating at the lowest expense, and for this reason it is necessary that only skilled men be employed. Of course, either solid fuel or gas can be used as a heating medium, but here

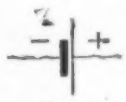


FIG. 1.

FIG. 2.

again the question of detail arises, with which we have nothing to do here.

It almost goes without saying that furnaces of this kind are not cheap, as both workmanship and materials must be of the best, owing to the expansion and contraction which occurs owing to variations in temperature. This may be eventually reduced on a series of years, when the new firebricks being introduced by the Morgan Crucible Company get into general use; but with these the first cost will be higher, the repairs and after costs being reduced by their use.

Given a good furnace and an intelligent man to work it, annealing should present no difficulty in securing the best results if due provision for allowing sufficient time is made. Necessarily the operator must understand the best temperatures for each class of metal dealt with, and also be something of a judge as to the time it is necessary to soak the articles to get the best results according to their bulk.

Chains and other lifting tackle should have considerable attention paid to annealing, while other things likely to become brittle through frequent alternating stresses should have proper attention, the whole question being an important one from the point of having safety insured as far as possible. Inefficient annealing is useless anywhere, but in cases where possibly life is at stake inefficient annealing is criminal, besides being costly from a pecuniary point of view.—The Practical Engineer.

ARRANGEMENT OF BATTERY CELLS.*

To secure the greatest efficiency in a battery the elements must be arranged so as to adapt the electro-motive force and the internal resistance to the resistance of the external circuit. To accomplish this the batteries are connected up in different ways, so as to yield currents of high voltage and low amperage, or the reverse.

To facilitate the explanation of the method of connecting batteries, it will be necessary to describe the conventional sign by which the element is designated. Fig. 1 represents the symbol or conventional sign for a single cell of any battery. The short, thick line represents the zinc, and consequently the negative pole of the battery, while the longer, thin line stands for the platinum, copper, or carbon plate, and the positive pole. The minus sign (—) is used to designate the negative pole, while the plus (+) is used to designate the positive pole.

When a number of cells are connected together, as

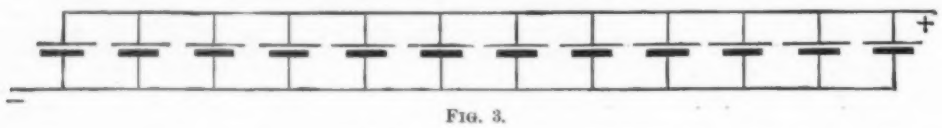


FIG. 3.

shown in Fig. 2, that is, with the positive pole of one cell connected with the negative of the adjoining cell, with the terminal cells connected with the conductors, the battery is connected up in series, and when so connected it yields the highest electro-motive force of which it is capable; that is to say, it yields the electro-motive force of a single cell multiplied by the number of cells in series.

A current of this kind is adapted to overcome high resistances. If a single cell of battery has an electro-motive force of 1 volt, then 12 cells of a battery connected in series would have an electro-motive force of 12 volts. Now, to secure the best effects with a battery, the external resistance through which the current must work should be equal to the internal resistance of the battery. In this case, if each cell of battery has a resistance of 5 ohms, the total resistance of the battery would be 60 ohms; therefore, a battery arranged in this way is best adapted to an external circuit having a resistance of 60 ohms.

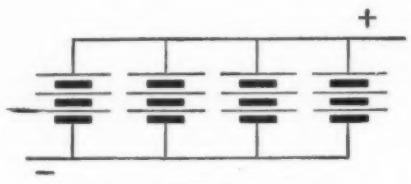


FIG. 4.

As the current is equal to the electro-motive force divided by the resistance $\left(C = \frac{E}{R}\right)$ in this case the electro-motive force being 12 volts and the total resistance of the circuit being 120 ohms, $C = \frac{12}{120} = 0.1$ ampere. We have then a current with the strength of 0.1 ampere, having an electro-motive force of 12 volts.

Perhaps the difference resulting from the methods of connecting up batteries cannot be better shown than by taking the opposite extreme. The 12 cells of battery are connected up in parallel circuit; that is to say, all the positive poles are connected with one conductor, and all the negative poles are connected with another conductor, as shown in Fig. 3. In this case each cell of battery having a resistance of 5 ohms, the total resistance of the 12 cells connected in parallel will be 1/12 of 5 ohms, which is a little more than 0.41 of an ohm, and the electro-motive force of a battery thus connected will be only that of a single cell, then making the external resistance equal to the internal resistance of the battery, the total resistance of the circuit will be 0.82 ohm. Now, by Ohm's law, $C = \frac{E}{R}$ we will have $\frac{1}{0.82} = 1.219$ amperes.

Where the cells are connected three in series, with four such series parallel, as shown in Fig. 4, the electro-motive force will be 3 volts (this quantity remaining the same for any number of series of three connected parallel). The resistance is inversely as the number of series, assuming the resistance to be 5 ohms per cell, the resistance of one series would be 15 ohms, and that of four series connected parallel would be $\frac{15}{4} = 3.75$. Now, making the external resistance of the circuit equal to the resistance of the battery, the total resistance of the circuit would be internal resistance 3.75 + external resistance 3.75 = 7.5 ohms; and by the formula $C = \frac{E}{R}$ we will have $\frac{3}{7.5} = 0.4$ ampere.

In Fig. 5 the cells are arranged in three parallel series of four each. The electro-motive force is 4 volts, the resistance of each series is 20 ohms; this, divided by the number of series = 6.66 ohms. Adding the resistance of the external circuit, which should be the same, the total resistance of the circuit would be 13.32 ohms. The electro-motive force, which is 4 volts, divided by this resistance = 0.3 ampere.

Take another example in which 12 cells are arranged in two series of 6 each. The electro-motive force will be 6 volts, the resistance 15 ohms, and if a similar resistance be added in the external circuit, the total resistance will be 30 ohms, and the current strength will be 0.2 ampere.

If, however, a resistance of 60 ohms be placed in the external circuit, with cells arranged as in Fig. 6, the total resistance of the circuit then being 75 ohms, the current strength would be $\frac{6}{75} = 0.08$ ampere, which is much less than that obtained by the first arrangement,

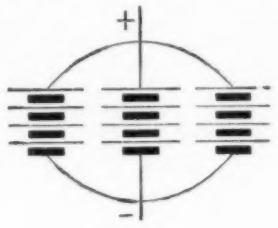


FIG. 5.

in which all the cells are in series. Or take the first example, in which all of the cells are in series, and make the external resistance 15 ohms, instead of 60. The current strength would be 0.16 ampere, but the extra strength would be attended with an undue loss in the battery.

It will thus be seen that by connecting cells in series the highest electro-motive force is secured, while

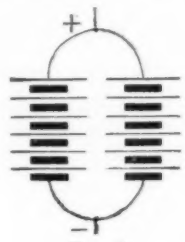


FIG. 6.

cells must be connected parallel for the greatest strength of current.

JOINT RESISTANCE OF BRANCH CIRCUITS.

The resistance of a conductor is directly proportional to its length and inversely proportional to its sectional area, and the conductivity of a wire is the reciprocal of its resistance. The conductivity of a wire having a resistance of 1 ohm is 1; that of a wire having a resistance of 2 ohms is ½; that of a wire having 3 ohms resistance is 1/3, and so on.

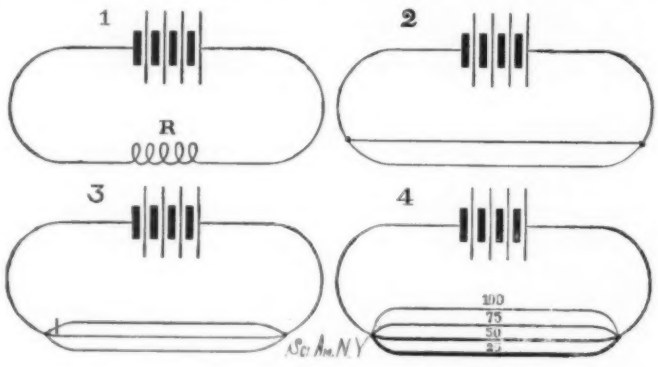


FIG. 7.

The joint resistance of two parallel conductors is, of course, less than that of either taken alone. The joint resistance of a divided circuit is ascertained by finding the conductivities of the different branches. The reciprocal of this result will be the joint resistance.

The method of determining the resistance (R) of a single conductor has already been explained. To find the joint resistance of the divided circuit, 2, Fig. 6, one branch having a resistance of 4 ohms, the other 8 ohms, the reciprocals of these numbers being respectively ¼ and ⅛, these added = ⅜, which is the joint conductivity. The reciprocal of this is 8/3 = 2.66 ohms. In a similar manner the joint resistance of three branches (3, Fig. 7) may be ascertained. Assuming the resistances to be 2, 5, and 10 ohms respectively, the reciprocals are 1/2, 1/5, and 1/10, which added = 8/10, which is the joint conductivity, the reciprocal of this 10/8 = 1.25 ohms, the joint resistance.

The joint resistance of four or more parallel conductors is found in the same way. In the case of the example shown at 4, Fig. 7, where the resistances are respectively 100, 75, 50, and 25 ohms, the joint resistance is 12 ohms.

Electrical measurements are made in a commercial way by means of instruments graduated so as to be read directly in ohms, volts, and amperes.

The principal difficulty with the gas engine, when applied to the driving of an electrical generator, appears in the fact that the piston receives a power impulse only at every other outward stroke, so that the turning moment is necessarily variable, and this gives a corresponding irregularity to the motion of the dynamo, unless some effective governing device is used.

* From "Experimental Science," by George M. Hopkins. Munn & Co., publishers, New York.

PRIMERS AND FUZES FOR CANNON.*

By Major ORMOND M. LISSAK, Ordnance Department, Instructor of Ordnance and Gunnery, U. S. M. A.

PRIMERS are the means employed to ignite the powder charges in guns.

They may be divided, according to the method by which ignition is produced, into three classes:

Friction primers.
Electric primers.
Percussion primers.

Combination primers are those so constructed that they may be fired by any two of the above methods. Primers that close the vent against the escape of the powder gases are called obturating primers.

All primers should be simple in construction, safe in handling, certain in action and not liable to deterioration in store. Electric primers in addition should be uniform as to the electric current required for firing.

The primer known as the *common friction primer*, formerly used in all cannon, is shown in Fig. 1.

The body *b* and the branch *d* are copper tubes. The tube *b* is filled with rifle powder, and is closed at its lower end by a wax stopper *a*. The tube *d* is filled with the friction composition, whose ingredients are chlorate of potash, sulphide of antimony, ground glass, and sulphur, mixed with a solution of gum arabic. Imbedded in the friction composition is the serrated end of the copper wire *c*, the other end of the wire being formed into a loop for attachment of the hook of the lanyard. The outer end of the tube *d* is closed over the flattened end of the wire, which is bent over into a hook, as shown, and serves to hold the wire securely in place except when a stout pull is given to the lanyard. The pull on the lanyard straightens out the hook, and draws the serrated wire through the friction composition, igniting it. The fire is communicated to the rifle powder in the tube *b*, and thence through the vent to the powder charge in the gun.

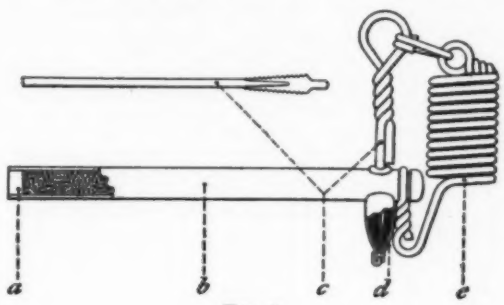


FIG. 1.

For use in axial vents, in order to prevent the primer being blown to the rear among the men of the gun detachment, a coiled copper wire *e* is added to the primer, one end of the wire being made fast to the top of the primer body, the other end to the loop for lanyard hook. The coil is extended by the pull of the lanyard, and the primer when blown to the rear remains attached to the lanyard.

Obturating Primers.—The primer above described is blown out of the gun by the explosion of the powder charge, leaving the vent open for the escape of gas. The disadvantage is overcome in modern practice by the use of obturating primers. The breech mechanisms of all guns now made are adapted to obturating primers, and the primer just described is no longer used in service cannon.

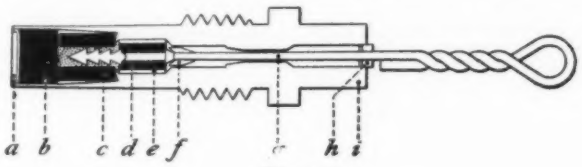


FIG. 2.

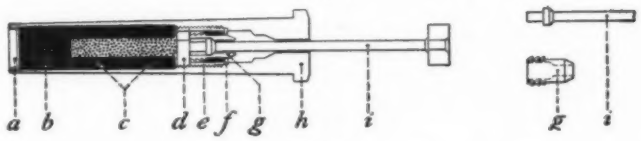


FIG. 3.

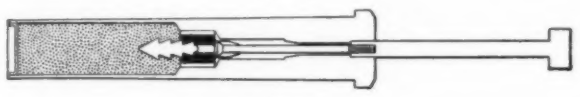


FIG. 4.

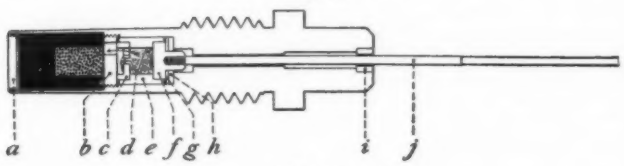


FIG. 5.

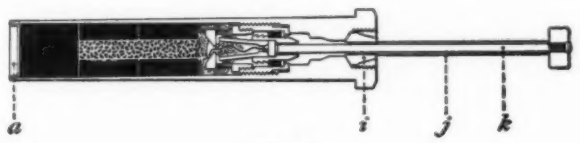


FIG. 6.

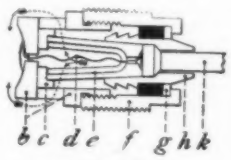


FIG. 7.

* Prepared for the cadets of the United States Military Academy and published in the Journal of the United States Artillery.

Screw Friction Primer.—This primer, Fig. 2, has a brass body *i* bored as shown. A pellet of friction composition *d* is molded around the shank of the serrated wire *g* just above the serrations. A paper cylinder *e* incloses the composition to prevent disintegration. The priming charge is composed of the two cylinders of compressed powder, *b* and *c*, and the loose rifle powder, which facilitates ignition. The safety block *h*, soldered to the wire *g*, prevents any forward movement of the wire through the pellet, which might cause premature firing in transportation or handling. The conical brass gas check *f* is loose on the wire *g*. A brass cup *a*, shellacked in place, closes the mouth of the primer.

The primer is screwed into its seat in the gun. When, by the pull of the lanyard, the serrated wire is pulled quickly through the pellet of friction composition, ignition occurs. The gas check *f* comes to a bearing in the coned seat in rear and prevents the escape of gas through the body of the primer. The primer fits closely in its seat in the gun, and at discharge the thin walls of its mouth are expanded against the walls of the primer seat, preventing the escape of gas around the body of the primer.

This primer was formerly in use in all siege and seacoast cannon. It has been superseded in seacoast cannon by the combination primer described later, but its use will be continued in the 3.6-inch and 7-inch mortars.

To assist in increasing the rapidity of fire of all guns a primer that can be more readily inserted in the gun is required. The desired object has been attained by the addition of firing mechanisms to the breech mechanisms of most guns, the firing mechanisms being so designed as to permit the use of a smooth-sided primer that can be readily pushed into its seat. The head of the primer is firmly held by the firing mechanism, so that the primer cannot be blown out on the discharge of the piece. The firing wire is engaged and pulled by a slotted lever actuated by the pull on the lanyard.

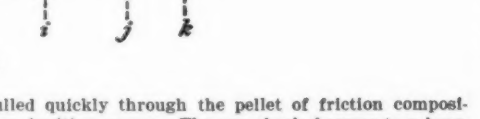


FIG. 12.

Friction Primer, Latest Pattern.—The primer, Fig. 3, has a body *h* of brass. The brass firing wire *i* passes loosely through the hole in the serrated cylinder *g*, the end of the wire being flush with the end of the cylinder when the nut on the wire bears against the interior shoulder of the cylinder. The friction composition, pressed into the brass case *e*, surrounds the cylinder *g* above the serrations. The vulcanite washer *f* holds the friction composition in place and prevents it from crumbling when the pull is applied. The nut *d*, screwed to a bearing on the case *e*, holds the assembled parts in place. Three holes through the nut permit the passage of the flame from the friction composition to the priming charge of powder.

When the wire *i* is pulled, ignition of the friction composition is effected. The conical end of the cylinder *g* is pulled to its seat in the body of the primer, and prevents escape of gas to the rear. Should the primer for any reason fail to fire, the wire *i* is now free to move forward without carrying the cylinder *g* and the friction composition with it, and therefore without danger of firing the primer in its reverse movement. In earlier models the teeth were formed on the wire, and it was found that when a primer had failed to fire it might be fired by an accidental reverse movement of the wire forcing the teeth quickly through the composition.

All metal parts of this primer are tinned to prevent corrosion.

Fig. 4 shows the more cheaply constructed drill primer of this form.

Electric Primers.—The electric screw primer, Fig. 5, is used in the 3.6-inch and 7-inch mortars, these guns being adapted for screw primers only. The single copper wire *j*, insulated with silk except at its outer end, passes through the vulcanite bushing *i* and the body of the primer to the brass obturating plug *f* into which it is screwed. The plug is insulated from the primer body by the vulcanite washer *h*, the leather washer *g*, and the vulcanite cylinder *e*. The platinum wire bridge *d*, 0.002 of an inch in diameter, is soldered to the plug *f* and to the brass washer *c*. The latter is put in electrical connection with the walls of the primer by the brass closing screw *b*. A small quantity of guncotton surrounds the platinum wire.

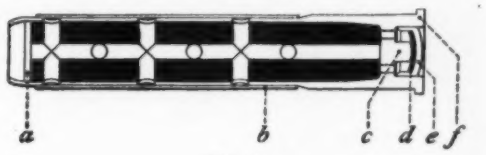


FIG. 8.

When the primer is inserted in the gun the base end of the wire *j* is grasped by the parts of an electric contact piece through which is passed in firing an electric current insulated from the gun. The current passes through the wire *j*, the platinum bridge and the body of the primer to the walls of the gun, and thence to the ground.

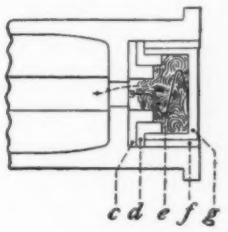


FIG. 10.

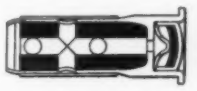


FIG. 9.

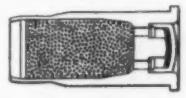


FIG. 11.

The passage of the electric current heats the platinum wire, igniting the guncotton and the priming charge of powder.

Another electric primer for use in a different breech mechanism is described after the 110-grain percussion primer.

Combination Electric and Friction Primer.—This primer is used in all seacoast cannon except those fitted for percussion firing.

The primer is shown complete in Fig. 6. The igniting elements enlarged are shown in Fig. 7. The parts of the friction elements of this primer are similar in construction and action to the parts of the friction primer shown in Fig. 3.

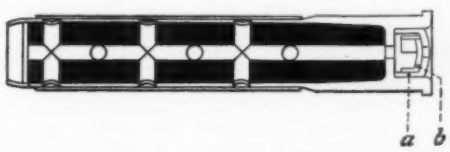


FIG. 13.

FIG. 14.

For electric firing the wire *k* is covered with an insulating paper cylinder *j* and enters the primer body through a vulcanite plug *i*. The wire is in electric contact with the serrated cylinder *h*, Fig. 7, but this is insulated from the primer body by the vulcanite washer *g* and the pellet of friction composition, a non-conductor of electricity.

The electrical elements of the primer are assembled in the metal case *f*. The head of the forked metal

support *e* is in contact with the headed end of the wire *k*, but not fastened to it. The forked end of the support is held in the vulcanite cup *c*. The brass contact nut *b*, screwed into the end of the case *f*, presses the assembled parts into intimate electrical contact. A platinum wire *d* is soldered to the head of the support *e* and to the contact nut *b*. An igniting charge of guncotton surrounds the wire.

The electric current enters the primer by means of the button on the outer end of the wire *k*, and passes through the primer and gun as described for the previous primer.

It will be observed that the friction elements of the combination primer are independent of the electrical elements, and that when one of these primers fails to fire by electricity it may still be fired by friction.

If, however, the primer fails in an attempt to fire it by friction, it will not generally be possible to fire it electrically since the cylinder *h*, which has been pulled into the head of the primer, is out of contact with the part *c* and the platinum wire bridge. The current will then pass directly from *h* through the primer body and gun to the ground.

The primer should in this case be at once removed from the vent, and not be again used.

The outer button and wire *k* may be turned without danger of breaking the platinum wire bridge *d*.

When an electric or friction primer fails to fire, it should be removed from the vent, and the wire bent down and around the primer to prevent attempts to use it again.

Percussion Primers.—The friction and electric primers described are used in guns in which the projectiles and powder charges are loaded separately, the primer being separately inserted in the breech block. Percussion primers, and the electric primer described with them, are, on the other hand, inserted in cartridge cases, in which are usually assembled both the projectile and the powder charge.

The essential parts of a simple percussion primer such as the cap in a small arm cartridge, are the primer cup, the anvil, and the percussion composition.

Formerly the percussion composition of all service primers contained a large percentage of fulminate of mercury. On account of the danger involved in handling mixtures containing the fulminate of mercury, its use as a primer ingredient in service primers manufactured at the Frankford Arsenal has been abandoned, and a mixture known as the H-48 composition is now employed.

This mixture contains the same ingredients as the friction composition, but in different proportions, as follows:

Chlorate of potash, 49.6
Sulphide of antimony, 25.1
Ground glass, 16.6.
Sulphur, 8.7.

To insure the practically instantaneous ignition of smokeless powder charges, the addition of a small charge of quick-burning black powder is required. This may be inserted in the base of the smokeless powder charge, or may be contained in the primer. It is desirable, on account of the smoke produced by black powder, and the fouling of the bore, that the quantity of black powder used be limited to the smallest amount that will produce prompt and complete ignition of the smokeless powder. The minimum amounts required for different charges have been determined and, for fixed ammunition, are contained in the percussion and igniting primers. These primers are inserted in the head of the cartridge case, in the position occupied by the primer in the small arm cartridge.

Two sizes of percussion primers, the 110-grain and the 20-grain, have been adopted for all guns from the 1-pounder to the 6-inch Armstrong inclusive.

110-Grain Percussion Primer.—The body *f* is of brass, 2.63 inches long. A pocket is formed in the head of the case for the reception of the metal cup *e* containing the percussion composition *d*. Projecting up from the bottom of the pocket is the anvil *c* against which the percussion composition is fired. Two vents are drilled through the bottom of the pocket. The priming charge consists of 110 grains of black powder inserted under high pressure into the primer body around a central wire. The withdrawal of the wire after the compression of the powder leaves a longitudinal hole the full length of the primer. Six radial holes are drilled through the walls of the primer and through the compressed powder. The compression of the powder increases the time of burning of the priming charge and causes the primer to burn with a torch-like rather than an explosive effect, making the ignition of the smokeless powder charge more complete. The holes through the priming charge increase the surface of combustion and the mass of flame, and direct the flames to different parts of the charge of powder, thus facilitating its complete ignition. The paper wad *a*, shellacked in the mouth of the primer, and the tin-foil covering *b*, serve to keep out moisture and to protect the primer from the impact of the powder grains when transported assembled in cartridge cases.

This primer is used in cartridge cases for guns from the 6-pounder to the 6-inch Armstrong gun inclusive.

The 20-Grain Percussion Primer, shown in Fig. 9, length 1.1 inches, is used in cartridge cases for 1-pounder sub-caliber tubes, 1-pounder machine guns, and 1.65-inch Hotchkiss guns.

110-Grain Electric Primer.—This primer, Fig. 10, is similar in form to the 110-grain percussion primer just described, and has the same priming charge similarly arranged. Ignition is produced electrically through the brass cup *g* to which one end of the platinum wire *e* is soldered. The cup is insulated from the body of the primer by the cylinder *f* and bushing *d*, both of vulcanite. The brass contact bushing *c*, to which the other end of the platinum wire is soldered, completes the electrical connection.

20-Grain Saluting Primer.—This primer, Fig. 11, costing less to manufacture than the 110-grain primer, is to be used in place of the latter with blank charges only. The primer contains a charge of 20 grains of loose rifle powder. As black powder only is used in blank charges, a smaller igniting charge answers.

The percussion primers and the electrical primer of the same form are so manufactured as to have a driving fit in their seats in the cartridge cases to which they are adapted, the diameter of the primer being from one and a half to two thousandths of an inch greater than the diameter of the seat. Special presses for the insertion of the primers are provided. The primer must not be hammered into the cartridge case. The primer seats in all cartridge cases using these primers are rough bored to a diameter about 20 per cent less than the finished size, and then mandreled to finished dimensions with a steel taper plug, to toughen the metal of the cartridge case around the primer seat. The toughening is necessary to prevent expansion of the primer seats under pressure of the powder gases, and consequent loose fitting of the primers in subsequent firings.

Combination Electric and Percussion Primer.—In Fig. 12 is shown a combination electric and percussion primer used in rapid-fire guns in the United States navy. Its construction can be readily understood from the figure. The insulation is shown by the heavy black lines. When fired by percussion the percussion cap is not directly struck by the firing pin, but by the point of a plunger forced inward by the blow.

Igniting Primers.—The igniting primers are for use in cartridge cases for sub-caliber tubes for seacoast cannon not provided with percussion firing mechanism. They contain no means of ignition within themselves, but require for their ignition an auxiliary friction or electric primer which is inserted in the vent of the piece in the same manner as for service firing. The flame passes from the service primer through the vent in the breech block to the igniting primer in the head of the cartridge case. The flame from the service primer would not be sufficient to ignite properly the smokeless powder charge in the cartridge case, and, therefore, the igniting primer is added.

The 110-grain and the 20-grain igniting primers, Figs. 13 and 14, differ from the corresponding percussion primers in the substitution of the obturating cup *a* and obturating valve *b*, both of brass, for the percussion cup and anvil. The obturating cup *a* is provided with a central vent to allow passage for the flame from the auxiliary primer. The obturating valve *b* is cup-shaped, and has three sections of metal cut away from its top and sides to allow passage of the flame. The valve *b* has a sliding fit in the cup *a*, and when the pressure is greater in front of the valve than behind it, the valve is forced to the rear and the solid top of the valve closes the vent in the outer cup.

The valve is shown in section in Fig. 13, in the position it assumes after firing; and in elevation in Fig. 14, in its position before firing.

(To be continued.)

ANCIENT ECLIPSES.*

By P. H. COWELL.

THE results of recent discussion of ancient eclipses may for convenience be divided into three sections. The conclusion of each section depends upon the truth of the conclusions of the preceding sections, but not *vice versa*, that is to say, the results of the last section may be rejected without in the least impairing the validity of the earlier conclusions. The results are as follows:

(1) If an astronomer had been asked a year ago by a historian or a chronologist whether the tables of the sun and moon accurately accounted for the recorded phenomena of ancient eclipses, he could only have replied that the tables failed altogether to account for the solar eclipses; that they had been empirically altered so as to account for the observed *times* of certain lunar eclipses; and that the question whether the tables so altered accounted for the *magnitudes* of the same lunar eclipses had not even been examined. There seemed to be no possible modification of the tables that would bring them into harmony with the recorded solar eclipses, and it was therefore the received opinion that the historical accounts of these were untrustworthy. The first result is that two slight modifications of the existing tables will cause them to satisfy the records.

The modifications in question may be stated as follows: Define the nodical month as the mean period between one passage of the moon from south to north of the ecliptic and the next passage, and define the nodical year as the mean period between one passage of the sun from south to north of the plane of the moon's orbit and the next passage, purely periodic variations being left out of account. Then the eclipses show that the rate of change of length of both the nodical month and nodical year as given in the tables must be altered.

(2) The second section of the results is concerned with the question, "In order to alter the rate of variation of the nodical year, are we to alter the acceleration of the node or of the sun?" Now the motion of the node depends upon theory, and the same theory which accounts for its motion at the present time will suffice to calculate its motion at any time during the last few centuries. The motion of the sun, however, is purely a question of observation. Unknown causes may easily be conceived as altering its motion. The second result is therefore to ascribe an acceleration to the sun's motion to account for the variation in the nodical year inferred from ancient eclipses, or in other words, we may leave out the word "nodical" in our statement and say, "The ancient eclipses indicate certain definite rates of change in the lengths of the month and year."

(3) We lastly require some physical explanation of the sun's acceleration. Here there are many possibilities. The ether may offer a sensible resistance to the passage of the earth; or an electro-magnetic theory of gravitation may compel us to take account of the small, but not infinitesimal, ratio between the velocity of a planet in its orbit and the velocity of light; or again, electrical theories of matter somewhat modify the old conception of mass, and with it the fundamental equations of motion on which planetary theory rests. But the explanation tentatively put forward at the April meeting of the Royal Astronomical Society is as follows: Let us suppose the acceleration of the sun to be due to a change in the length of the day caused by tidal friction. The tides check the rotation of the earth, lengthen the day, and therefore apparently increase all diurnal movements by the same fraction of their whole amounts. Introducing numbers for greater definiteness, let us suppose that in a century the day increases in length by a two-hundredth part of a second of time. Then in a century the sun's apparent rate of motion will increase by one part in seventeen million, which is exactly the change indicated by the eclipses. If, however, the moon's apparent rate of motion also increased by one part in seventeen million the acceleration would be ten times larger than that indicated by the eclipses.

But if the tides are checking the diurnal rotation of the earth, it follows from the principle of conservation of angular momentum that the moon must be receding from the earth, and absorbing the spin lost by the earth. This implies that the moon is really moving more slowly. It is impossible to make accurate calculations, for the action of the tides on an earth with oceans and continents of irregular shape cannot be computed, and it is impossible to say how the tidal action varies for different positions of the moon in its elliptic orbit. Hence we cannot say how far the action of the tides is distributed between changes in the length of the month and changes in the eccentricity of the moon's orbit. But it seems a plausible hypothesis that the large eccentricity of the moon's orbit was evolved somehow, presumably by tides, and that the eccentricity is therefore increasing, and calculation shows that if the rate of increase assigned to the eccentricity be about one-hundredth of a second of arc a century, the consequent change in the absolute angular velocity of the moon is such as to cancel nine-tenths of the apparent decrease in the length of the month, leaving the remaining one-tenth in agreement with the change inferred from ancient eclipses. This explanation, it should be clearly understood, only shows that certain correlated quantities are of the right order of magnitude: it is unable to prove or disprove an exact numerical relation.

In the remaining part of this article the basis of the conclusion of the first section is examined. That is the foundation, which must be rendered secure before interest can attach to any superstructure.

Let us select a definite eclipse, for instance, the eclipse of Thucydides in the first year of the Peloponnesian war. The record states that stars appeared. It is certain on the other hand that the eclipse, at the most, could only have been annular. There is therefore a strong presumption that Athens was not far from the central line of the eclipse, or in other words, at the time of conjunction in longitude as seen from Athens, the difference of apparent latitudes must have been small. The hypothesis that Athens was the place of observation has been objected to. This, however, is the natural interpretation of the passage in Thucydides; let us adopt it for the present and see where it leads. For Athens, therefore, let the difference of apparent latitude for the instant of apparent conjunction in longitude be computed from the present tables. The result is so large as absolutely to negative the possibility that stars could have been seen. Reserving the hypothesis that the record is untrustworthy as a last refuge in case of trouble, let us suppose for the present that the tables require alteration.

What kind of alteration is permissible? It has been argued in Ast. Nach., No. 3682, on physical grounds, that only one unknown quantity may be introduced. Now against physical reasoning of this kind, strong objections may be urged. It proceeds necessarily on the assumption that the general nature of the problem of the apparent motions of the sun and moon is fully understood. It absolutely limits the investigation to the numerical determination of quantities connected with a preconceived theory, and it prevents, at the outset, the attainment of results of a new character. Now as the preconceived theory was entirely based upon two centuries of observation, there is no improbability in our knowledge being widened, when the period of observation is largely increased. In the whole of astronomy there is not a single case of a theoretical value of a secular term, that is to say, a term proportional to the square of the time, being confirmed by observation. This is because the series of modern observations is not yet long enough. Is it not possible that one or two centuries hence the ob-

* Nature.

served values of these terms will lay bare a whole series of new phenomena? Physical considerations of the kind alluded to absolutely prevent the achievement of such a result. They may advantageously be replaced in the following manner by considerations of a purely geometrical character.

It being, for a time at least, granted that the eclipse of Thucydides suggests that the existing tables require large modifications, geometrical considerations tell us that in order to diminish by 200 sec. or thereabout the difference of latitude at conjunction, we must alter the mean distances of the sun and moon from the node as given by the tables for the year—430 by quantities of the order of 2,000 sec. The only geometrical alternative is to assume alterations ten times as large in some other quantity such as the position of the perigee, and this alternative may be put aside. Now the mean distances can be expanded in powers of the time, the origin of time being taken near the present day. Then modern observations forbid the correction of the mean motions or of the terms independent of the time. The corrections are therefore necessarily thrown about the coefficients of the square of the time, that is to say, upon what are called the secular terms, in the mean distances of the sun and moon from the node. Geometrical considerations, therefore, combined with a becoming modesty as to our powers of applying physical considerations, present us with two unknown quantities for correction, one of which is the quantity admitted in Ast. Nach., No. 3682, to be arbitrary, while the other is a new one.

If the preconceived theory is correct and the records are trustworthy the value of the second variable will on solution turn out to be zero or so nearly zero as to suggest that zero is the true value. If no values satisfy all the equations of condition, then some of the records are untrustworthy or the geometrical considerations have been carelessly thought out. If the equations can be satisfied simultaneously, and the value of the second variable is not zero, a very strong case is established against the physical considerations of the preconceived theory.

If we write down five simultaneous linear equations in two unknown quantities x and y, all satisfied by the same values of the variables, and if we then put y equal to zero, or in other words, rub out the terms in y, we shall of course find the equations in x are inconsistent. If the equations represent historical data, and if, as men of science, we have a proper contempt for literature, we shall no doubt proceed to quarrel with our evidence. This is exactly the way in which astronomers have in the past treated ancient solar eclipses. When, however, equations of condition involving two unknown quantities are formed for all the solar eclipses in which the place of observation appears to have been fairly near the central line, whereas modern tables give residuals of the order of 200 sec., that is to say, make the apparent differences of latitude at conjunction in longitude of the order of 200 sec., values can be found for the unknown quantities, which will make all the residuals less than 50 sec.; in other words, whereas the present tables would leave about ten per cent of the sun's diameter visible, the alterations proposed never leave so much as two per cent visible.

Let it be here stated that no solar eclipse is an exception to the above statement. The conclusions rest not upon the evidence of a majority, but upon the unanimous evidence of all eclipses used. A list of these is given in Monthly Notices, lxv., p. 861, and a reference is given on p. 867 to the eclipse of Agathocles. The eclipse of Thales has not been worked up, as it occurred a hundred years before the birth of Herodotus; its evidence, whether for or against, is held to be inadmissible.

A confirmation of these results is supplied by the lunar eclipse of the Almagest. On working them up, it is found that the residuals are so large as to show that they are entitled to far less weight than the solar eclipses. Their value lies in the fact that the separate determinations from the lunar eclipses group themselves round the values derived from solar eclipses. The lunar eclipses are given in Monthly Notices, lxvi., pp. 6, 7; they are nineteen in number, and in only ten cases is a numerical estimate of the magnitude recorded. These ten cases alone, therefore, test the newly-discovered fact which, in language that becomes appropriate only if the second section of results is admitted, states that the earth's orbital motion is subject to a secular acceleration of 4 sec. Now of the ten lunar eclipses available, seven give accelerations lying between 2 sec. and 6 sec. It is therefore hard to believe that zero and not 4 sec. is the correct value. The times of the lunar eclipses are equally striking in their confirmation of the result. Nearly thirty years ago a correction was introduced into Hansen's Tables based upon these eclipses. The main question is one of evidence. It is no use to point out in the third section of this paper how certain changes may be accounted for, if they are not shown to exist. On the other hand, no objections to a particular explanation of the physical reason can weaken the case for the observed fact that these changes are taking place. What is sufficient evidence? Two eclipses would suffice, if they had been described with a wealth of detail that established complete confidence in the records. A hundred eclipses of the actual sort would probably satisfy the most skeptical, even though the place assigned were always "tacitly assumed (to be) the capital where the record was made, or the place where the poet or historian lived." The smaller number of eclipses, which it has alone been possible to produce, should suffice to make a case almost if not completely amounting to certainty.

SCIENCE NOTES.

An extension of technical education is to be noticed in our large cities where technical schools have opened their doors in the evening and have invited students, employed during the day, to enter and learn what they can. These night schools are exceedingly common in England, so common that they have undermined the influence of the regular day schools and have implanted the erroneous idea in the mind of the average young Englishman that he can work all day, go to school at night, and still be successful in each case. Such we know to be fallacious. The true conception of night school work is that it is only a means of securing essential facts, but is not education in its truest sense. The Germans have not made this mistake and emphasize the necessity of giving undivided attention either to educational work or to industrial work, but not to combine the two. Interesting in connection with evening instruction by technical schools is the use of local centers or technical clubs, with home-rule organization, but with the same end in view.

Although the study of the physiology of reproduction may be said to have had its origin in the early observations of Camerarius, all early studies represented largely only the ecological aspect of the subject. It is only in very recent years that rapid strides have been made in the general physiology of reproduction. The effect of conditions upon the production of antheridial or archegonial thalli or of pistillate or staminate flowers among diœcious and polygamous plants has received very slight attention. During the present year Laurent has published the results of experimentation during a period of seven years with the effects of fertilizers, or plant nutrients, upon spinach, hemp, and *Mercurialias annua*. It will be seen that according to his results an excess of nitrogen or calcium has a tendency to produce staminate flowers in the spinach, while potassium or phosphorus tends to increase the production of pistillate flowers. The seed produced on the pistillate flowers of these plants gave a preponderance of female plants; but from these plants, in turn, the seed yielded a larger number of staminate plants. It has never been determined if in a case of diœcious perennial plants it is possible by a change of conditions to induce a temporary or permanent change from pistillate to staminate flowers, or *vice versa*. In the same way, the influence of grafting or budding a scion of one upon the other has not been made out, although it is assumed that the flower will be characteristic of the scion.

An interesting example of the organization of migratory birds on their departure to their nesting haunts is afforded every year by the gray geese of the Arctic circle off the coasts of the Outer Hebrides of the British Isles. These birds, including the young reared during the previous season, come south to these inhospitable and inaccessible islands off the coast of Scotland every October for the winter, the return to the Arctic zone being made at the end of March or during the first days of April. For several days previous to the migration the birds congregate at one spot, and one may see on such occasion thousands of the geese lining the shore and packed so closely together that there is scarcely room for them to move. At the psychological moment one of the older birds, evidently the king of the flock, rises into the air. Simultaneously the waiting birds give vent to wild shrieks, but make no attempts to rise until a peculiar call is given by the leader overhead. Then some fifty birds take wing and form themselves into a solid triangular phalanx, three birds in line forming the apex, and swiftly they follow in the wake of the leader toward the north. When the flock has been thoroughly started on its journey, the leader leaves them and returns to the waiting hordes on the coast, when the same process is repeated, and is continued until all but some three hundred veteran birds have been left behind. When the leader returns for the last time these all rise together, form a triangular wedge as in the previous cases, and rapidly pursue the preceding flocks. The younger birds are in the front, and should any of them fall out or straggle from their particular body and lose their way, they are picked up again by the last huge corps of birds in the rear. In this way may be seen a long stream of triangular wedge-shaped armies of birds for a distance of a hundred or more miles flying swiftly over the water toward their breeding grounds in the North.

The subject of the different compounds of iron and molybdenum has been taken up by M. Ed. Vigouroux, of Paris. He obtains a number of definite compounds and describes their properties. The ferro-molybdenums have a certain interest from a metallurgical standpoint. In his account of the researches, M. Vigouroux states that the operations were carried out by the aluminothermic method and also by direct combination at a high heat. In the former case, pure oxide of iron and oxide of molybdenum, MoO_2, are mixed with aluminium filings and placed in a magnesia crucible, where the mixture is ignited in the usual way. However, in order to have the compounds free from any traces of aluminium, the direct action of the two metals is obtained by using pure reduced iron and reduced molybdenum. The compressed mixture is placed on magnesia troughs inside a porcelain tube traversed by a current of hydrogen. By heating the tube in a Schloesing furnace to 1,450 deg. C., the combination of the two metals is effected. In this way they formed a series of alloys of iron and molybdenum having various proportions. They isolated three alloys forming distinct compounds, Fe_2Mo, containing 46.20 per cent of molybdenum, Fe_2Mo_3, with 53.37 per cent, Fe Mo with 63.20 per cent, and Fe Mo_2 having 77.45 per cent. These bodies are characterized by their property of contraction and their non-magnetism. They have a gray color and are insoluble in hydrochloric acid, but nitric acid dissolves them. Continuing their researches, they describe the leading properties of these new compounds. The body Fe_2Mo is a gray metallic substance whose density at 0 deg. C. is 8.90. It is non-magnetic. Chlorine attacks it slowly when cold, but after 250 degrees the action is violent and the alloy disappears in the form of red fumes. Oxygen and sulphur act upon it at redness with incandescence, and water vapor attacks it even below redness. It dissolves in sulphuric and nitric acids. Potash in solution has no effect, but it has a strong action when in fusion. As regards the second compound, Fe_2Mo_3, it has a density of 9.16. It is non-magnetic and its properties closely resemble those of the former body. The third compound Fe Mo has a density of 9.01. It becomes incandescent in chlorine at 285 deg. C., and in oxygen at a red heat. Like the others, it is attacked by acids, etc. Nitrate of potash in fusion acts strongly upon it. The body Fe Mo_2 has a density of 9.41. Chlorine attacks it with incandescence at 305 deg. C. and oxygen at 350 degrees. In general its properties are the same as mentioned for the other bodies. Alkaline carbonates and nitrates act more strongly upon these bodies according to their proportion of molybdenum.

ELECTRICAL NOTES.

There is a class of machine tools where the size of motor required depends very largely on the machine itself, almost independent of the size of cut it has to take; this is the reciprocating tool, as the shaper and planer, and to a somewhat less extent the intermittent working machines, such as punches and shears. In planers where shifting of belts is relied on to reverse the motion, the statement is fairly accurate; in tools where the reversal takes place by magnetic clutches or motor reversal it is not so much so, as the power taken by the motor can be better regulated. In planer drives where motor runs continuously in one direction, it is of relatively little importance how much the platen or the load on it weighs, but the size and weight of the revolving pulleys which have to reverse it are of very great importance. These pulleys should be as small and light at the rim as capacity will allow; and on one of the revolving shafts, preferably on the motor shaft, there should be a fly-wheel of large diameter and heavy rim so as to aid the motor at moment of reversal.

In any moderate or leisurely cycle of charge and discharge, it is known that the quantity efficiency, or ampere-hour efficiency, of a storage cell is nearly 100 per cent, and that even under hand labor the ampere-hour efficiency does not fall greatly below 100 per cent. It is the watt-hour or energy efficiency which suffers under stress. Under laboratory conditions of most careful and light loading, the watt-hour efficiency can be brought up to nearly 100 per cent, while under heavy and severe loading in practical service this efficiency may fall to about 70 per cent. According to the Electrical World and Engineer, in some experiments by Prof. B. F. Bailey two storage cells, each of 160 ampere-hours capacity, were allowed to charge and discharge 60 times per second, at 20 amperes effective current. That is, the normal eight-hour discharge rate was reduced to the 1-60th of a second, or 1-216,000th of an hour, a period 1,728,000 times shorter than the normal. The experiments showed a quantity efficiency of almost 100 per cent, and a watt-hour efficiency of 98.1 per cent under these conditions. The loss of charge in the cell subjected to this short but merry cyclic activity appears to have been less than when the cell was allowed to remain idle, on open circuit.

The commercially successful system of motor-speed control may be grouped under three classes: two-wire systems, three-wire systems and four-wire systems. The two-wire systems make use of a single voltage and a motor capable of large speed variations by field regulation. Until recently it was not found practical to make a variation in speed of more than thirty per cent in this manner, as the tendency of the motor to spark became excessive at the higher speeds and weak fields. Improvements in motors now permit of speed ranges of 2 : 1 or 3 : 1, and in the case of certain very special motors as much as 6 : 1, with fairly satisfactory results. The sizes of motors required for these large ranges become, however, very great as compared with the size of constant-speed motors of the same output, or even as compared with variable-speed motors on the three or four-wire system. The two-wire system is one, nevertheless, of great promise for situations where the others are not deemed advisable. The most common three-wire system makes use of 230 volts between mains and 115 volts between each main and neutral. This gives two speeds directly on the voltages. The increase by field regulation necessary to bridge the gap between them is nearly 100 per cent, and the same increase is usually made above the 230-volt speed as well. The total range then becomes 4 : 1. The three-wire system is also used with uneven voltages, as, for instance, 77 and 153, respectively, between the neutral and the outside wires, the main voltage being 230. Then 100 per cent increase by field regulation is necessary above 77 volts and 50 per cent above 153 volts. If 100 per cent can be used above 230 volts a 6 : 1 range is obtained. With 50 per cent above 230 volts the range becomes 4.5 : 1.

ENGINEERING NOTES.

The strength of concrete is not diminished by a small amount of clay or loam in the sand or other parts of the aggregate. Experiments seem to show that rather dirty sand gives just as good results as cleaner sand, when the two are used side by side, with the same cement. A patented wall plaster in the market, consisting of a small proportion of cement and a large proportion of clay, becomes very hard and is very durable when used; as far as it goes, this is evidence that a reasonable amount of clay or loam is not harmful as regards strength or hardness. It is not certain, however, that the weathering qualities of such concrete are not damaged, and, on the whole, it seems safer to have the sand and other materials as clean as possible.

The evaporative efficiency of a locomotive is generally maximum when the power delivered is least. Under conditions of maximum efficiency, most of the boilers tested at St. Louis evaporated between 10 and 12 pounds of water per pound of dry coal. The efficiency falls as the rate of evaporation increases. When the power developed is greatest, its value commonly lies between limits of 6 and 8 pounds of water per pound of dry coal. The observed temperature of the fire-box under low rates of combustion lies between the limits of 1,400 deg. F. and 2,000 deg. F., depending apparently upon characteristics of the locomotive. As the rate of combustion is increased, the temperature slowly increases, maximum values generally lying between the limits of 2,100 deg. and 2,300 deg. F. The smokebox temperature for all boilers, when worked at light power, is not far from 500 deg. F. As the power is increased, the temperature rises, the maximum value depending upon the extent to which the boiler is forced. For the locomotives tested, it lies in most cases between 600 deg. and 700 deg.

A modern blast furnace plant will be equipped in the future with extensive gas cleaning apparatus to cleanse all the gas produced by the furnaces. Aside from the advantage of obtaining a higher temperature in the hot-blast stoves, thus decreasing the quantity of gas necessary for heating the blast and eventually decreasing the coke consumption per ton of pig iron produced, there is a decided advantage in using clean gas for heating the stoves, as the latter do not require to be cleansed as often. This would mean a considerable saving in labor actually expended in the blast furnace plants for removing the dust which accumulates in a very short time in the flues of the hot-blast stoves. It would even be possible by using clean gas to do away entirely with the spare hot-blast stoves, thus saving considerably on the first cost of the installation. As the gas-washing apparatus delivers the gas under a pressure of from three to four inches of water, the size of the conduits for conveying the gas could be decreased for new blast furnace plants, which again would mean a reduction in the first cost.

The chief points in which the ordinary gas engine fails are: (1) Bad governing, (2) ignition troubles, (3) difficulty in starting, (4) great floor space necessary. The ordinary hit-and-miss governor is not very suitable for electric lighting. In running several gas-driven dynamos in parallel, difficulty is often experienced owing to the interchange of current between the machines; this variation is accelerated as the load decreases owing to the number of explosions per minute becoming less. Such a governor would, of course, be quite useless for controlling engines driving alternators in parallel. Recently another form of governor for gas engines has been introduced working on the throttle system. This governor acts upon the regulator valve which controls the admission of both gas and air to the mixing chamber. As the load on the engine varies the regulating valve moves up or down, increasing or decreasing the quantity or volume of the mixture without altering the quality. The frequency of the impulses is, therefore, the same for all loads, the relative quantities of gas and air remaining constant. Given a suitable engine, governed in this manner, there is no practical difficulty in running direct-coupled alternators in parallel, and the author understands that there are several such plants in successful operation. The chief objection to an engine governing on the throttle is that, owing to the fact that the explosive mixture is never entirely cut off, compression at the lower loads is decreased owing to the reduced volume of gas and air admitted at each charge. This, although it may appear at first sight a serious objection, is really not of great importance. The following figures are the guarantees given by two engine makers for engines of similar size—one throttle-governing, the other hit and miss:

Comparative Consumption of Gas Engines in Cubic Feet per Brake Horse-power. Gas, 150 B.T.U.

Load.	Throttle governing.	Hit-and-miss.
Full	66.6	66.6
¾	77.5	73.5
½	88.0	86.5
¼	110.0	100.0

The tube system of ignition has been largely superseded by electrical methods. In one supply station enormous trouble was experienced owing to pre-ignition. This difficulty was largely overcome by adopting electric ignition, and finally totally eliminated by water-cooling the pistons and exhaust valves. The high-tension system of ignition is exceedingly reliable, and causes little or no trouble.

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